AD-A104 183 ELECTRONIC SYSTEMS DIV HANSCOM AFB MA F/G 17/2
ASSESSMENT OF TACS-2000 CONCEPTS AND TECHNOLOGY.(U)
JUL 81 J K MORRIS
UNCLASSIFIED ESD-TR-81-140 NL

1 OF 1
AD A
104183

END
DATE
FILMED
10-81
DTIC

10

ESD-TR-81-140

AD A104183

ASSESSMENT OF TACS-2000 CONCEPTS AND TECHNOLOGY

JOHN K. MORRIS, Maj, USAF
Deputy for Development Plans
Electronic Systems Division
Hanscom Air Force Base, MA 01731

July 1981

Approved for public release;
distribution unlimited.

Prepared for

DEPUTY FOR DEVELOPMENT PLANS
ELECTRONIC SYSTEMS DIVISION
HANSCOM AIR FORCE BASE, MA 01731

81 9 14 124

The Public Affairs Office has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

LEGAL NOTICE

When U.S. Government drawings, specifications or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

OTHER NOTICES

Do not return this copy. Retain or destroy.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.

John K Morris

JOHN K. MORRIS, Major, USAF
Chief, C^3I Architecture Division
Deputy for Development Plans

FOR THE COMMANDER

Anthony Napoli

ANTHONY NAPOLI, Colonel, USAF
Director, Tactical C^3I Systems Planning
Deputy for Development Plans

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (14) ESD-TR-81-141 ✓	2. GOVT ACCESSION NO. AD-A104	3. RECIPIENT'S CATALOG NUMBER 283
4. TITLE (and Subtitle) (6) ASSESSMENT OF TACS-2000 CONCEPTS AND TECHNOLOGY.		5. TYPE OF REPORT & PERIOD COVERED (9) Final rept. 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Maj John K. Morris		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Deputy for Development Plans (ESD/XR) Electronic Systems Division Hanscom AFB, MA 01731		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16) PE 63789 Proj 2478
11. CONTROLLING OFFICE NAME AND ADDRESS Deputy for Development Plans (ESD/XR) Electronic Systems Division Hanscom AFB, MA 01731	(11)	12. REPORT DATE July 1981 (12) 13. NUMBER OF PAGES 80 76
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Concepts, Command and Control, Tactical Air Control System, TACS-2000

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is based on efforts of the Electronic Systems Division Deputy for Development Plans and the Rome Air Development Center Tactical Air Control System (TACS)-2000 Working Group during the period 25 Nov 80 until 6 Mar 81. It describes in general terms the battlefield environment in which the future deployable Tactical Air Control System (TACS) will be employed, goals and alternative system concepts for the future TACS, and briefly assesses the

DD FORM 1 JAN 73 1473

Unclassified 227100

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20 Abstract Continued

ability of the Air Force's current technology program to support realization of the concepts.

PREFACE

This report is based on efforts of the Electronic Systems Division Deputy for Development Plans and the Rome Air Development Center Tactical Air Control System (TACS)-2000 Working Group during the period 25 Nov 80 until 6 Mar 81. It describes, in general terms, the battlefield environment in which the future deployable Tactical Air Control System (TACS) will be employed, goals and alternative system concepts for the future TACS, and briefly assesses the ability of the Air Force's current technology program to support realization of the concepts. The purpose of this report is to serve as a catalyst for discussion among the planning, technological, developmental, and user communities concerning future tactical command and control.

TABLE OF CONTENTS

			PAGE
Section	1.	INTRODUCTION	7
Section	2.	BACKGROUND	11
Section	3.	OPERATING ENVIRONMENT AND GOALS	13
Paragraph	3-1.	Introduction	13
	3-2.	Deployable TACS Definition	13
	3-3.	Assumptions	13
	3-4.	Threat	14
	3-5.	Scenario	15
	3-6.	System Goals	16
	3-7.	Activity Goals	20
	3-8.	Other Functions	22
Section	4.	SYSTEM CONCEPTS	25
Paragraph	4-1.	Introduction	25
	4-2.	Distributed Concepts	26
	4-3.	Highly Distributed Concept	26
	4-4.	Distributed Concept	37
	4-5.	Semi-distributed Concept	45
	4-6.	Airship Concept	53
	4-7.	Remote Concept	53
	4-8.	Airframe Dependent Concept	53
Section	5.	CONCEPT EVALUATION	59
Paragraph	5-1.	Introduction	59
	5-2.	Assessment	59
	5-3.	Surge Phase, All Concepts	60
	5-4.	Sustained Phase	60
Section	6.	TECHNOLOGY ASSESSMENT	63
Paragraph	6-1.	Introduction	63
	6-2.	Annotation	63
	6-3.	General Capabilities	63
	6-4.	Air Surveillance, ID, Airspace Control	64
	6-5.	Surface Surveillance and ID	66
	6-6.	Force Management	67
	6-7.	Communications	68
	6-8.	Summary	71
Section	7.	CONCLUSIONS	73
Section	8.	RECOMMENDATIONS	75
Section	9.	APPENDIX A	77

LIST OF ILLUSTRATIONS AND TABLES

FIGURE		PAGE
1.	Current Tactical Air Control System............	8
2.	Future Tactical Battlefield....................	10
3.	Highly Distributed Concept, Surge Operations...	28
4.	Highly Distributed Concept.....................	30
5.	Highly Distributed Communications..............	32
6.	Highly Distributed Air Surveillance, Air Identification, and Airspace Control...........	34
7.	Highly Distributed Surface Surveillance and Identification................................	36
8.	Highly Distributed Force Management............	38
9.	Distributed Concept............................	40
10.	Distributed Communications.....................	41
11.	Distributed Air Surveillance, Air Identification, and Airspace Control...........	42
12.	Distributed Surface Surveillance and Identification................................	44
13.	Distributed Force Management...................	46
14.	Semi-Distributed Concept.......................	47
15.	Semi-Distributed Communications................	49
16.	Semi-Distributed Air Surveillance, Air Identification, and Airspace Control..............................	50
17.	Semi-Distributed Surface Surveillance and Identification................................	51
18.	Semi-Distributed Force Management..............	52
19.	Airship Concept................................	54
20.	Remote Concept.................................	56
21.	Airframe Dependent Concept.....................	57
TABLE		
1.	Concept Evaluation.............................	58

1. INTRODUCTION

1-1. A new class of sensor and weapons systems now in development, such as the Precision Location and Strike System (PLSS), PAVE MOVER System, and Wide Area Anti-Armor Munitions (WAAM), will bring major changes to the tactical battlefield of the future. These systems are designed to efficiently detect, locate, identify, and destroy large numbers of relatively small targets such as emitters and tanks. They can store or predict target locations and later guide stand-off weapons with sufficient kill radius to the appropriate position.

1-2. In a major conflict, expeditious use by friendly forces of the great quantity of timely surface target information which future sensors make available will be critical to battle outcome. At the same time, should the enemy develop and deploy sensor and weapons systems similar to those described in paragraph 1-1 (the Soviet Union's history of borrowing from our successful developments and its already massive Radio Electronic Combat (REC) capability suggests the probability of such Soviet developments), in a counter command and control (C^2) role, the positioning of today's deployable Tactical Air Control System (TACS) will be impractical within the battle zone. Figure 1 depicts the essential features of the current deployable TACS which, for the purpose of this report, includes all deployable Air Force command and control system elements used in a theater to support airborne operations. The term "command and control system" is defined as the facilities, equipment, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned. The C^2 system includes supporting communications and intelligence functions.

1-3. Today's system is composed of:

a. Elements which are large, conspicuous, soft, unable to move, and within reach of the enemy's weaponry.

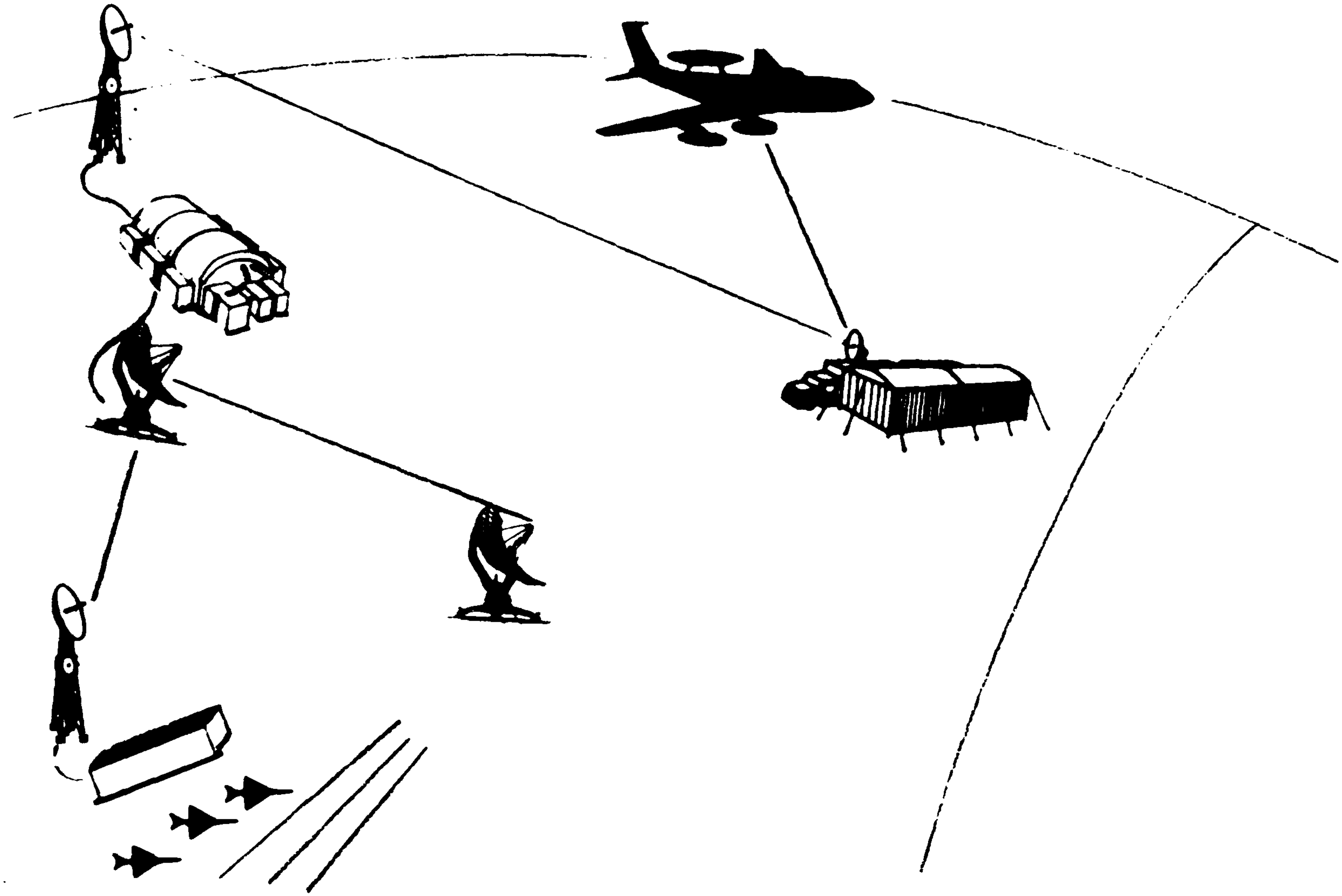

FIGURE 1. CURRENT TACTICAL AIR CONTROL SYSTEM

b. Manned elements which are closely associated with emitters.

c. Facilities and communications which tend to parallel the hierarchical command structure making that structure readily apparent to enemy analysis.

1-4. Today's deployable TACS depends on:

a. A few key facilities like the Tactical Air Control Center for conducting C^2 functions.

b. Limited and inferior back-up capabilities.

c. Communications which are typically of insufficient capacity routed through vulnerable nodes.

1-5. In a high intensity conflict, present TACS elements will become increasingly vulnerable at the same time when the efficient use of PAVE MOVER and similar capabilities, on our part, puts a premium on the availability and processing of information about the battle and on the means for force control and direction. Current development programs make few provisions for ensuring battle information will be available during the degraded operations that can be expected under combat conditions. Information systems which rely on automation, yet have no back-up capability, become a liability when they are lost. Figure 2 is a representation of the tactical battlefield of the future with PAVE MOVER System, PLSS, and WAAM-type capabilities deployed by both sides. Information will be a major asset for the successful conduct of warfare. It must be anticipated that both sides will invest in systems to obtain information as well as in counter-systems to deny it to the other side.

1-6. New ideas are needed to enable the deployable TACS to meet the increased demand for information, and at the same time, survive the intense threat forseen in a future major conflict. It is expected that the configuration and operation of the TACS will evolve to take advantage of system concepts which permit increased survivability through the application of modern technology.

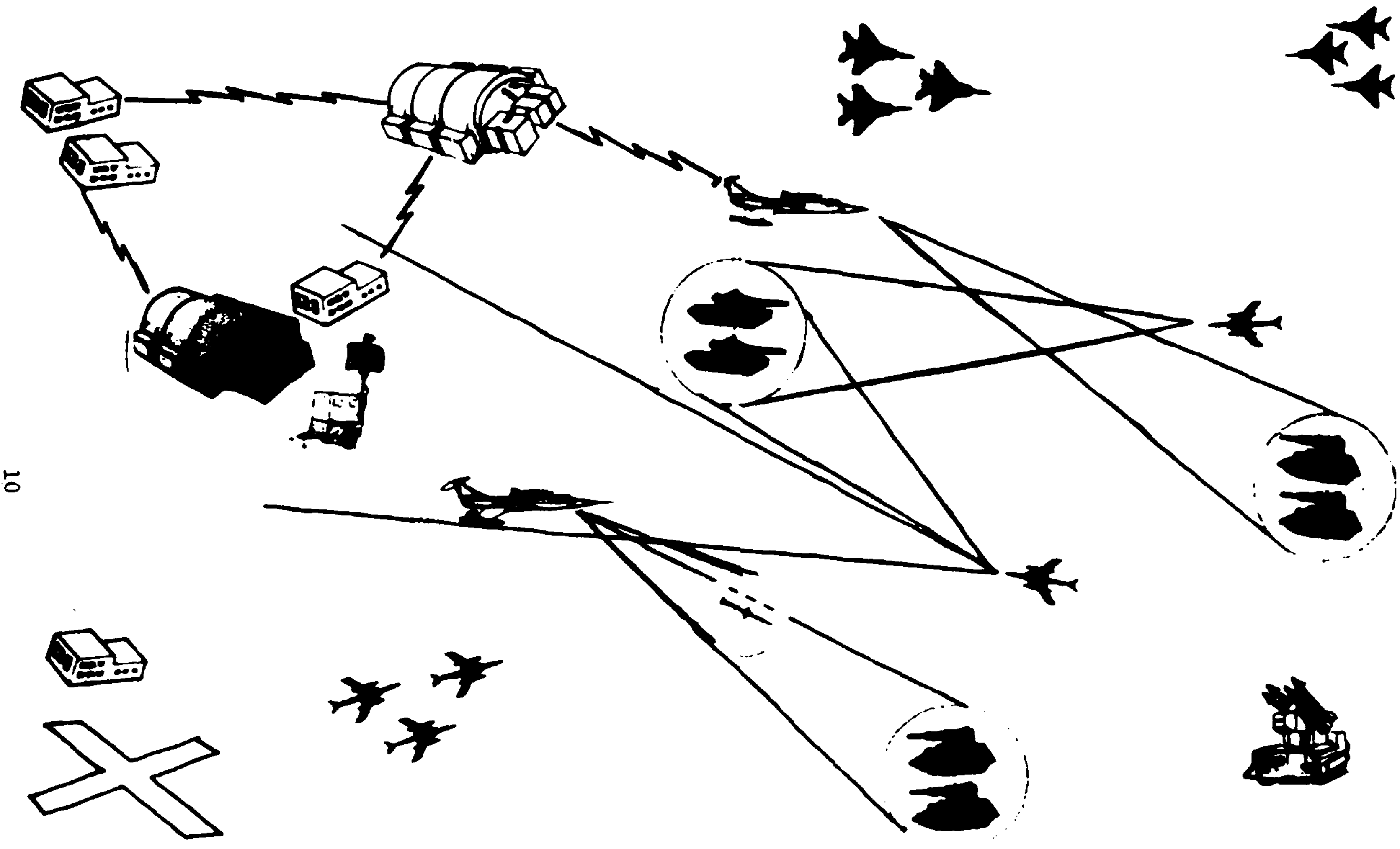

FIGURE 2. FUTURE TACTICAL BATTLEFIELD

2. BACKGROUND

2-1. Late in July 1980, the Air Force Systems Command Directorate of Command, Control, and Communications (AFSC/XRK) requested the Electronic Systems Division Deputy for Development Plans, Tactical C^3I Systems Planning Directorate (ESD/XRT) develop a briefing which would illustrate a concept for the evolution of the future Tactical Air Control System. The concept would be used to provide an objective goal to guide technology and systems acquisition. In response, ESD/XRT prepared a strawman briefing for a concept called TACS-2000. It closely paralleled the Highly Distributed concept discussed in this paper. On 20 Aug 80, this concept was briefed to an O-6 level working group sponsored by AFSC/XRK, and including representatives from the Tactical Air Forces Interoperability Group, Tactical Air Command, United States Air Forces in Europe, Pacific Air Forces, Air Force Systems Command, and Air Staff. The distributed system concept was endorsed by the working group.

2-2. At a subsequent briefing, the Commander of the Rome Air Development Center (RADC/CC) expressed the desire to make the Air Force's command, control, and communications (C^3) technology program responsive to the new concepts. A joint ESD/XR and RADC working group was formed to define and evaluate alternative concepts capable of coping with the broad spectrum of warfare intensities which must be considered when planning technology developments for a comprehensive capability such as a TACS. As a point of departure, the scope of the working group effort was limited to the deployable TACS. The group had four primary tasks:

a. Define the operating environment and goals for the future deployable TACS.

b. Develop system concepts and subconcepts which satisfy the environmental constraints and goals of the previous task.

c. Evaluate the concepts and their associated subconcepts.

d. Identify major technologies required to implement promising concepts.

2-3. This paper is based on the results of the working group effort. The effort was accomplished in-house, intermittently over a period of approximately three months.

3. OPERATING ENVIRONMENT AND GOALS

3-1. Introduction.

This section describes the future operating environment (assumptions, threat, scenario) and goals for the future deployable Tactical Air Control System in general terms for use in defining and evaluating alternative system concepts. The section covers:

a. Deployable TACS Definition.

b. Assumptions.

c. Threat and Scenario: In general terms, the environment in which the deployable TACS will be deployed.

d. System and Activity Goals: Goals pertaining to the system as a whole and for each activity of the system (Air and Surface Surveillance and Identification, Force Management, Airspace Control, and Communications).

3-2. Deployable TACS Definition.

The deployable Tactical Air Control System is defined as a set of assets, transportable worldwide, which allows the Air Force Component Commander to effectively plan, direct, coordinate, and control tactical air operations and to coordinate air operations with the other services and allies. These operations include offensive and defensive counterair and defense supression, close air support, reconnaissance and surveillance, airlift, special operations, and combat support air operations (air refueling, electronic warfare, rescue and recovery, psychological and chemical warfare, and collateral operations).

3-3. Assumptions.

To establish a framework for projecting the TACS into the next century, the following assumptions are made:

a. Tactical air operations will be generally the same as those listed in paragraph 3-2. Details of the operations may change due to advancements in technology or in response to changes in the threat.

b. The purpose of the TACS as defined in paragraph 3-2 will be generally the same.

c. The principles of centralized control (authority and responsibility vested in a single air commander with an established line of succession) and decentralized execution (higher echelons of command define missions and tasks, lower echelons conduct the operations) will be maintained.

3-4. Threat.

a. The threat to the deployable TACS is dependent on the time and theater of employment. The deployable TACS of the future should have the capability and be designed to respond adequately (not necessarily perfectly) to the spectrum of warfare to include operation under the most severe threat expected. It should possess a capacity for additional improvements should a greater actual threat areise.

b. In general, the most intense threat to the deployable TACS will be encountered in a conflict with our most capable adversaries, the Soviet Union and its allies. In such a war, the deployable TACS will face:

(1) Highly capable tactical air forces.

(2) Rapidly moving and capable surface forces.

(3) Accurate missiles and long range guns.

(4) An effective enemy C^2 structure.

c. In the electronic domain, it can be expected that the threat will include:

(1) Surface, airborne, and space-based jammers.

(2) Chaff, deceivers, SIGINT, and EMP.

(3) Efficient theater-wide sensing and locating systems capable of accurately mapping an C^2 system and holding the coordinates of C^2 elements selected as targets.

d. The physical threat may include:

(1) Bombs (gravity and guided).

(2) Remotely guided wide area anti-armor type weapons.

(3) Tactical nuclear, chemical and biological weapons.

(4) Anti-radiation missiles (ARM), anti-satellites (SAT), laser and particle beam weapons.

e. Lesser threats can be expected in conflicts involving second and third world powers.

3-5. Scenario.

a. The deployable TACS must be capable of responding to a variety of contingencies, ranging from peacetime operations through counterrevolutionary, insurgency, and other low intensity conflicts involving a limited geographical area, through theater conventional and theater nuclear warfare. The initial spectrum of conflict and intensity will vary depending on the specific location, threat, and the enemy's political objectives. For the purpose of examination, three distinct and representative phases are considered:

(1) Surge: The first Air Force actions in an emerging theater. No US surface forces are yet deployed (presently in the

theater). The associated C^2 capability is relatively simple and can be made quickly available. Emphasis is on quick, decisive, and controlled action rather than full capability. Duration of this phase is generally limited.

(2) Build-up: Additional Air Force elements and joint surface forces are introduced into the theater. The C^2 needs are expanding and may vary widely during this phase. This is a transitional state.

(3) Sustained: Total theater-wide warfare involving joint or combined operations. The associated Air Force C^2 capability will be extensive and reach its most complex level. The sustained phase will continue for the duration of the conflict.

b. Once action has been initiated, a considerable period may elapse before transitioning to a higher phase; or the transition may occur rapidly, depending on the specific situation. Additionally, warfare in more than one phase may exist in the theater at any given time. In any case, escalation of the conflict in intensity and enemy capabilities is likely to occur as hostilities progress. During any phase, all assets within the theater may be subject to attack although the enemy will have to pay a higher price to reach those further from the Forward Edge of the Battle Area (FEBA) or in defended areas. Lastly, pre-existing assets may range from none to a major US or allied capability.

3-6. System Goals.

Capability goals for the deployable TACS are presented here for use in concept development and evaluation. They include goals which pertain to the overall TACS and to each of its activities at the total systems level. Activities are defined as the major jobs to be done by the TACS. These activities are: Air Surveillance and Identification, Surface Surveillance and Identification, Force Management, Airspace Control, and Communications. Where specified, particular goals may apply to some or all elements (sub-units) of the future TACS.

a. Survivability (physical): In all tactical warfare environments, the system should:

(1) Be capable of avoiding or minimizing the effects of physical attack.

(2) Be capable of sustaining C^2 functions.

(3) Protect subsystems and elements at a level commensurate with their function and importance.

(4) Be able to operate in varying intensities of combat.

b. Survivability (Chemical, Biological, and Radiological (CBR)): The system should be capable of maintaining operations in chemical, biological, and radiological environments. CBR protection should be an integral part of each element.

c. Survivability (Electronic). The system should operate in an electronic countermeasure (ECM) environment without unacceptable degradation.

d. Graceful Degradation. The system design should ensure that the performance of the overall function diminishes gradually as individual elements are lost by destruction or failure. Essential functions must be sustained even if degraded. As automated capabilities degrade, the system must be able to concentrate on the most essential tasks. Finally, a rudimentary capability to manually conduct selected functions should be maintained. The system should permit the Air Force Component Commander the flexibility to determine which are the most essential functions at the time and reassign his C^2 assets accordingly.

e. Reliability and Maintainability. System availability should not be limited to any significant extent by mean time before failure (MTBF) or mean time to repair (MTTR). Subsystem reliability should be commensurate with function and importance. The system should:

(1) Utilize equipment designed to minimize system failures, maintenance down time, and maintenance personnel requirements.

(2) Be maintainable by military personnel.

(3) Include a system verification capability.

f. All environment operation. The system should be capable of sustained operations in any theater and natural environment.

g. Interoperability. The system should:

(1) Be designed as a total functional entity. Subsystems and elements, even if individually acquired, should be conceived, configured, and developed as a distinct piece of a total capability,

(2) Be designed for joint service operations.

(3) Be capable of interface with allied systems.

(4) Provide interface with other AF, theater and national C^2 systems.

h. Mobility. The system should:

(1) Be adequately mobile to keep pace with forces being supported (the primary purpose of mobility is intra theater movement. The contribution of mobility to element survivability depends on the enemy's target detection to weapons delivery time-cycle. In the future, as the enemy's cycle shortens, detectable elements will quite likely find it increasingly difficult to outrun this cycle).

(2) Provide for element set-up and tear-down commensurate with mobility cycles of the function performed by that element. An element that must move frequently should have relatively short set-up and tear-down times.

i. Deployability. The system should:

(1) Be readily air transportable for worldwide Bse.

(2) Upon arrival in theater, be capable of limited operations in a partial or initial deployment configuration and be able to commence operations in a "stand alone" configuration or integrated with existing systems.

j. Flexibility. The system should:

(1) Permit timely reconfiguration, while operating, to changing situations and needs particularly during, or in response to, losses. It should permit the commander freedom to operate in the way that he perceives best at the time.

(2) Be adjustable in size to meet small contingencies or full scale conflict.

(3) Permit growth with the needs of the operation.

k. Supportability. The system should:

(1) Use a minimum number of personnel (operations and maintenance) reducing current TACS manning requirements.

(2) Permit reduced dependency on fossil fuels.

(3) Individual elements should be capable of self-sustained operations over a limited time period.

(4) Elements should carry their own power source.

l. The system should:

(1) Use human engineering considerations to maximize personnel efficiency.

(2) Incorporate built-in exercise generation capabilities where practical.

(3) Be achieveable through evolutionary implementation.

3-7. Activity Goals.

a. The TACS activities are:

(1) Air Surveillance and Identification: The process of providing an accurate and current picture of the air situation.

(2) Surface Surveillance and Identification: The process of providing an accurate and current picture of ground or ocean surface activity.

(3) Force Management: The act of assessing situation; planning; coordinating; allocating and directing tactical air resources.

(4) Tactical Airspace Control: The support provided to all tactical operations from takeoff to recovery with a focus on assisting friendly airborne weapons systems in intercepting air and surface targets or carrying out their assigned missions.

(5) Communications: The means for information exchange among the surface and airborne assets of the deployable TACS and between the TACS and weapons systems and external C^2 systems.

Systems to accomplish each activity should not only meet the overall system goals enumerated in paragraph 3-6 above, but in addition, meet their own activity-unique goals. Activity goals are:

b. Air Surveillance and Identification (ID):

(1) Detect, track, identify, and classify all air targets.

(2) Provide a complete and current picture of the air situation at appropriate locations.

(3) Be capable of providing reliable threat alert and assigning specific targets (including their identification) to both air and surface weapons systems.

(4) Provide for joint system-wide operations with other service assets (Army, Navy, Marines).

c. Surface Surveillance and ID:

(1) Detect, locate, identify, and classify all fixed and mobile targets of interest in a timely manner. Timeliness requirements will vary according to information usage. Applications will range from immediate closed-loop use in weapons guidance to long term use in force management functions.

(2) Provide complete and current situation data at appropriate locations.

(3) Cooperate with other service sensor, fusion and targeting operations.

d. Force Management:

(1) Enable the best use of available information for the effective employment and management of all resources available to the commander.

(2) Maintain present status and situation of enemy forces, assigned forces, friendly forces, and operational environment.

(3) Provide decision making aids to assist the commander assessing the impact of alternative decisions.

(4) Provide mission planning and execution aids (graphic or tabular information).

(5) Provide automated order generation and distribution.

(6) Provide mission assessment and status up-date.

e. Tactical Airspace Control:

(1) Provide continuous, timely, and adequate support to aircraft (manned and unmanned) engaged in all tactical air operations with a focus on assisting in the intercept of air and surface targets.

(2) Provide airport traffic control, enroute control, and navigation.

f. Communications:

(1) Provide assured connectivity.

(2) Provide adequate capacity.

(3) Provide the means to eliminate unacceptable delays.

(4) Provide adequate quality and intelligibility.

(5) Provide appropriate security for information as well as preventing enemy traffic and operations analysis.

3-8 Other Functions.

In addition to the operating environment, system goals, and activity-unique goals, concepts for the deployable TACS must also consider the implications of and interfaces with other functions.

These implications and interfaces have yet to be fully considered. Some functions in this category include:

a. Mobility: airlift and air refueling.

b. Logistics: supply and maintenance.

c. Medical.

d. Personnel.

e. Training.

f. Intelligence.

g. Weather.

4. SYSTEM CONCEPTS

4-1. Introduction.

Six candidate concepts were developed, each independently, by the TACS-2000 working Group. They include:

a. The Airship concept: a unique concept calling for C^2 elements to be located in high altitude (25K-30K meters) rigid balloons.

b. Two concepts, which rely extensively on a specific mode of operation.

(1) The remote concept postulates that the majority of C^2 functions can be carried out remotely from a sanctuary area outside the theater of war.

(2) In the Airframe Dependent concept, all C^2 elements within the theater are located on aircraft. During the sustained phase of warfare, the system operates with the majority of the aircraft on the ground parked in revetments. A back-up airborne capability is available in times of emergency.

c. Three concepts characterized primarily by distributed surface-based elements. These concepts also incorporate certain features from other modes of operation including remote and airframe dependent. The three concepts span the spectrum of distribution. They are distinguished by their specific degree of distribution and hence the survivability of their surface elements. They are the:

(1) Semi-Distributed concept.

(2) Distributed concept.

(3) Highly Distributed concept.

d. Under each of the six concepts, subconcepts were developed for the areas of: Air Surveillance and Identification and Airspace Control, Surface Surveillance and Identification, Force Management, and Communications. In addition, the configuration of each concept and subconcept was defined for the three postulated phases of warfare: surge, build-up, and sustained.

4-2. Distributed Concepts.

a. The three distributed concepts will be presented first. Here, the term "distributed" incorporates four thoughts:

(1) It refers to the overall systems level, not the internal element level (for example, the distribution of work stations within an element).

(2) Individual elements of the system are physically separated from each other.

(3) Functions are dispersed among elements in such a manner that, as much as possible, each element can completely do its assigned function.

(4) There is redundancy. That is, should any element and its associated function be lost, that function exists elsewhere within the system.

b. The concepts presented in this section represent discrete points in a continuum of possible distribution. The Highly Distributed concept and its associated subconcept and phase descriptions will be presented first followed by the concepts of lesser distribution: the Distributed and Semi-distributed.

4-3. Highly Distributed Concept.

a. Surge Phase.

(1) The Surge phase of the Highly Distributed concept is depicted in figure 3 and represents the Air Force's first presence in a tactical theater. The concept for the year 2000 differs little from similar operations today. It is essentially a long range totally airborne Tactical Air Control System capability for the command and control of tactical air operations with as many functions as possible being carried out remotely.

(2) Air and surface surveillance and identification would be accomplished by a number of airborne sensors, netted together to develop the required air and surface coverage. Output from this sensor system would be combined with other data and displayed aboard an airborne force management aircraft located in the theater of operations. Only essential force management tasks would be carried out in the theater with the remainder being performed remotely. All communications within the theater are air-to-air. An airborne satellite communications (SATCOM) capability is used to connect the airborne TACS with its home station out of theater. All communications would be high capacity, secure, and jam resistant.

(3) Most of the airborne elements, which compose the deployable TACS during the surge phase, would be used during operations in later phases as well. During the build-up and sustained phases, airborne air surveillance sensors extend the coverage of surface-based radars. Airborne surface surveillance sensors continue to be the primary source of surface situation data. As certain areas of the theater transition through the build-up into the sustained phase, the surge phase may shift to other parts of the theater.

b. Build-up phase. During the build-up phase, the TACS transitions from an airborne capability to a surface based operation by the time-phased introduction of the deployable surface elements: utility communications elements, command and control elements, radar elements, etc. Elements would be airlifted into the theater in a sequenced manner to give a basic operating capability from the beginning and a smooth transition from airborne

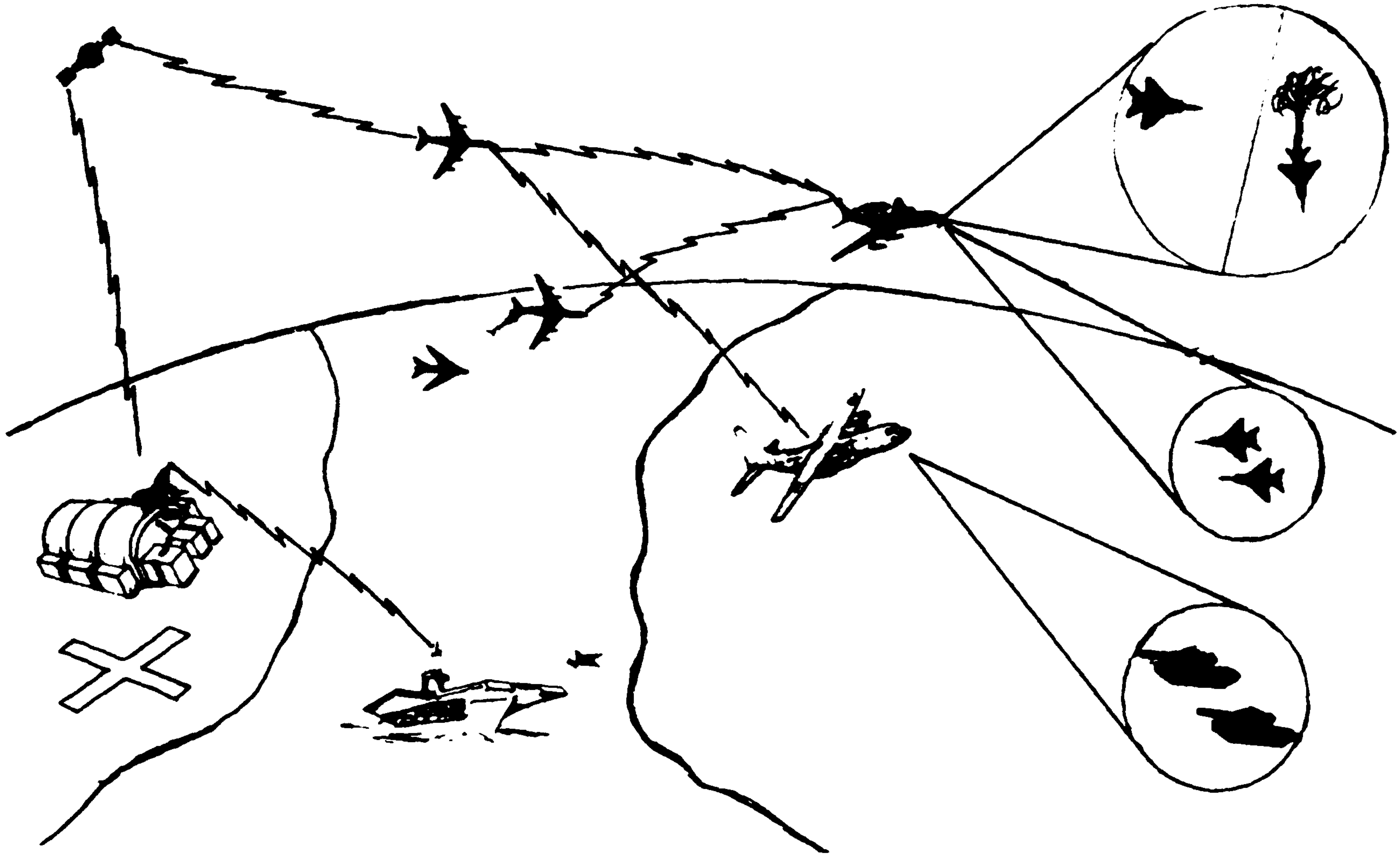

FIGURE 3. HIGHLY DISTRIBUTED CONCEPT, SURGE OPERATIONS

operations. Operations from the surface elements could commence almost immediately upon their arrival within the theater. Capabilities would increase with the introduction of additional numbers of elements. TACS operations and activity features during the build-up phase are essentially the same as during the sustained phase and are described in the next paragraph.

c. Sustained phase.

(1) To attain survivability of command and control in a high threat environment, the Highly Distributed concept relies upon distribution of C^2 functions, physical separation of elements, and the flexibility to reconfigure during operations to reduce the effects of enemy action. Reliance is placed on a utility communications network to provide assured connectivity, unifying the distributed functions intc an operating entity.

(2) Figure 4 is a representation of the forward area network of the Highly Distributed system. Although the system would support automomous Air Force operations, it is designed to operate as part of a joint service network. This is done to provide the numbers of sensors and communications elements required to assure system survivability in the high threat areas, to assure full sensor coverage in the face of enemy countermeasures, and to pool all available information on air and surface targets among the services. In figure 4, a portion of the utility communications system is depicted (5 mobile communications elements with a silent spare in the center). The utility communications system ties together all system sensors such as the mobile forward-area radars and the airborne air and surface-based sensors, as well as the manned C^2 elements (two of which are depicted as the leftmost vehicles in the illustration). To provide a capability to move with the joint forces and the flow of battle, most system elements are mobile and carry their own power sources. Routine system operations are automated to the greatest possible extent.

(3) Communications. The highly distributed concept envisions a utility communications net which will operate as a

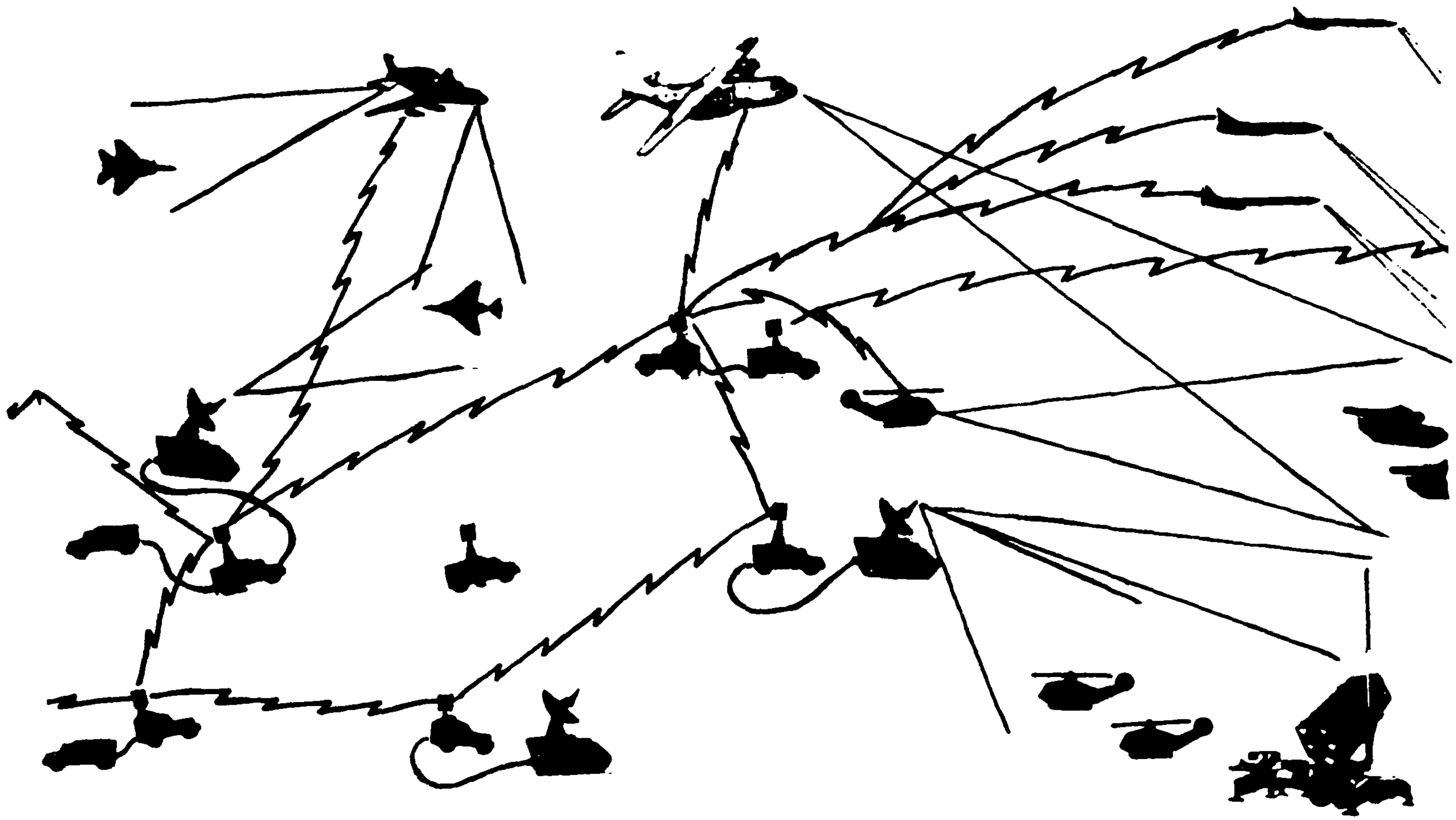

FIGURE 4. HIGHLY DISTRIBUTED CONCEPT

joint (and ideally combined) network to tie together the elements of the distributed C^3I system. It is designed to provide, with a high degree of assurance, the required capacity for its users. Individual radiating elements cannot be hidden from sophisticated sensors. However, the network achieves survivability through a multiple routing capability. In this concept, the enemy is unable to link individual communications elements with the specific command and control elements they service. Individual elements "hide in the crowd" (are numerous and indistinct to the enemy). Being integrated with a joint and allied network furthers this objective and facilitates information exchange as well. The network is primarily deployed in the battlefield area equivalent to the Army Brigade to Corps level. It would extend into the forward areas, to serve elements close to the front, by tying in with appropriate Army battalion and lower echelon nets. At the rear, it would be connected with more traditional forms of communications. The network is composed of mobile elements which automatically align their links selecting the communications mode which propagates best at the time and location. Links would be highly directional, primarily short range, and narrow beam with longer hop options, such as troposcatter or SATCOM, available for bridging gaps. Each link will transmit a continuous bit stream, individually encrypted to protect traffic flow from enemy exploitation. Customers may use additional end-to-end encryption for data or voice requiring special protection. The net will be self-maintaining to include element location, link alignment, key distribution, and net entry. Automatic, network-wide routing, frequently moving elements, and silent spares contribute to the overall survivability of the communications network function. Disassociating the communications elements from the command and control elements they serve increases the survivability of the command and control function. The Highly Distributed communications network, shown in figure 5, has alternate routings via SATCOM and troposcatter in use to maintain connectivity due to loss of some of the network elements. The silent spare in the foreground is moving to replace one of the lost elements. Secure jam resistant air-ground-air communications is facilitated by the integration of ground-to-air radio or Joint Tactical Information

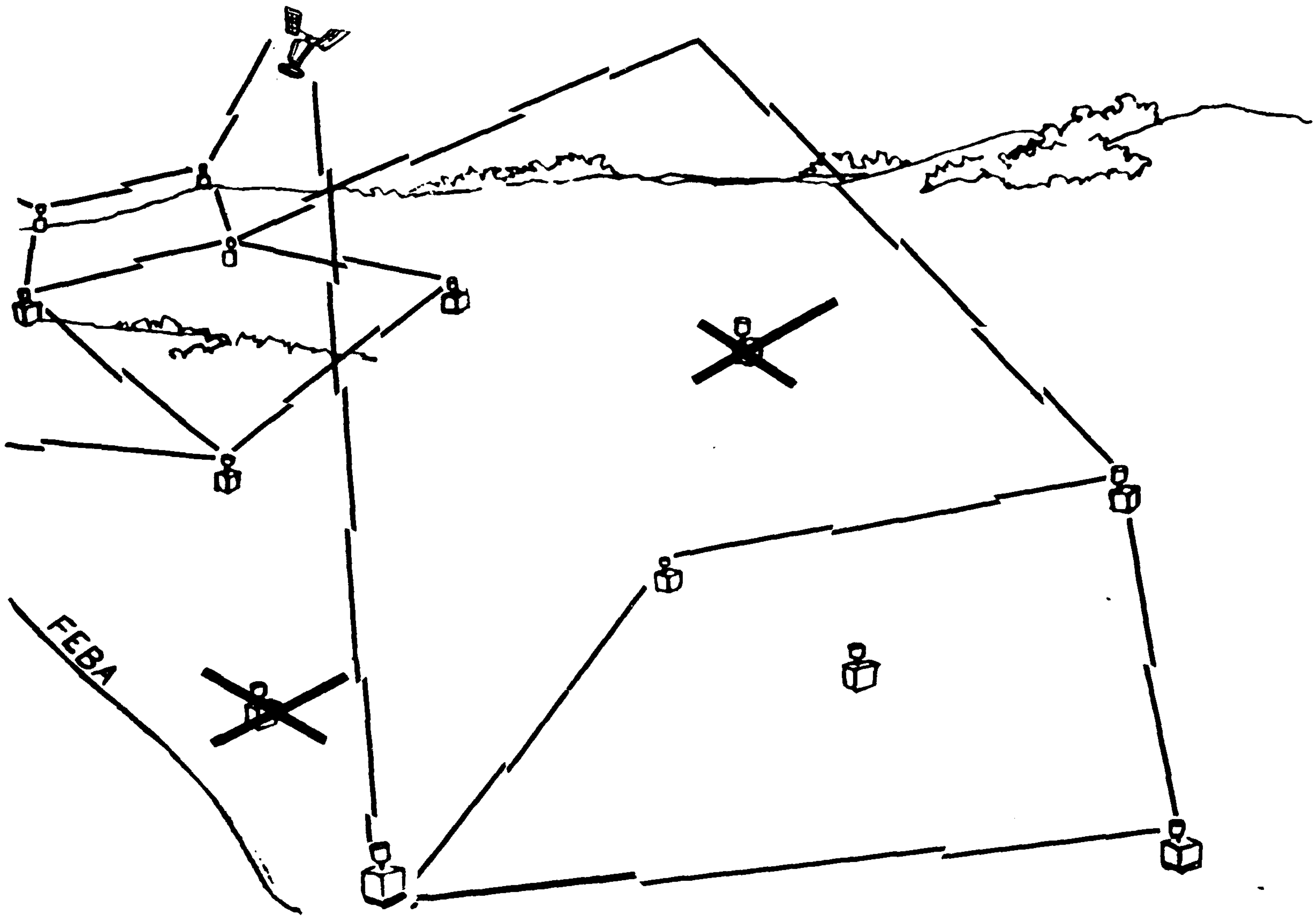

FIGURE 5. HIGHLY DISTRIBUTED COMMUNICATIONS

Distribution System (JTIDS) terminals into the communications elements.

(4) Air Surveillance and Identification and Airspace Control.

(a) The Highly Distributed concept envisions that, in the future, air surveillance is accomplished via a unified theater-wide system, accepting inputs from all available sensors (including joint and possibly allied) and serving all users (see figure 6). The network is highly automated and does not depend on operators for its routine functions. It processes and distributes its information automatically with the information being tailored to functional needs. In this way, forward area radars collectively provide continuous overlapping low altitude coverage for all targets over the battle area. These radars frequently move, enter, and leave the net. Some remain silent or operate in a passive mode to increase enemy uncertainty, functional survival, and total system performance. Airborne sensors such as the E3A tie into the forward area net as integral elements. More traditional long-range radars provide high altitude cover in the rear areas where survivability is not as demanding. Air situation information supplied to the user is tailored to meet his specific functional requirements. Elements of the air surveillance network are integrated on a "plug in" basis by the redundant, self-organizing, utility type communications network described in the preceding paragraph.

(b) Air identification is accomplished via the air surveillance network. Once an initial identification of the aircraft has been made, by whatever means available (intelligence input, point of origin, pilot report, etc.), the associated track will be tagged with this information. The complete and contiguous coverage available from the system is a requisite for reliably passing identification to other theater elements or weapon systems. The ability to alert air or surface based weapon systems, to cue their sensors before they need to radiate, to assign them hostile targets, and to prevent them from attacking friendly aircraft is an

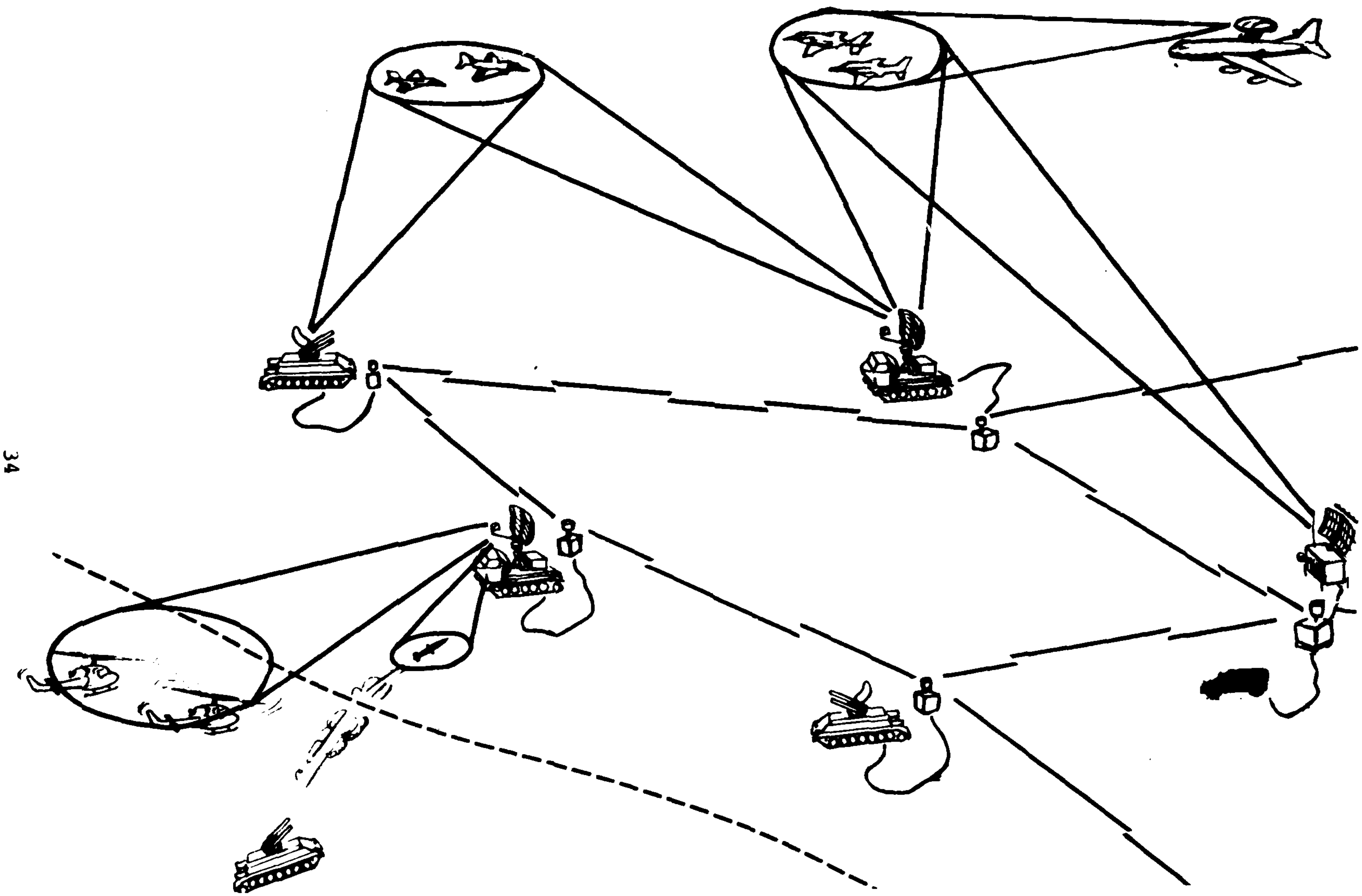

FIGURE 6. HIGHLY DISTRIBUTED AIR SURVEILLANCE, AIR IDENTIFICATION, AND AIRSPACE CONTROL

important capability of the future which the air surveillance and identification system will support.

(c) The air and surface surveillance and identification networks provide the information required to assign manned or remotely piloted aircraft to intercepts of air and surface targets. Individual mission, rather than geographically, oriented airspace control or flight following elements support and assist their assigned aircraft from takeoff through landing by using air and surface surveillance information from wherever available within the network. Alternatively, the system is capable of providing digital data describing the combat environment directly to the airborne weapons. Data includes target description, identification, and relative location, as well as weapons system position, threat location, weather, etc. and is transmitted ground-to-air over JTIDS links.

(5) Surface Surveillance and Identification. Surface surveillance and identification is accomplished in an analogous manner to air surveillance and identification. A joint service surveillance network accepts inputs from all available sensors and distributes the information with the appropriate level of detail and area coverage to all users. Uses of this information range from guiding aircraft to surface target interceptions to providing a total theater-wide surface situation picture to the Air Force Component Commander. Figure 7 shows the Highly Distributed surface surveillance network.

(6) Force Management.

(a) Survival of the force management capability in the high threat environment of the future requires a distributed operation. Force management functions must be distributed among physically separated elements in such a manner as to permit the flexibility to reconfigure or reassign functions during wartime operations. Distributed functions require assured communications to enable the force management capability to perform as an entity.

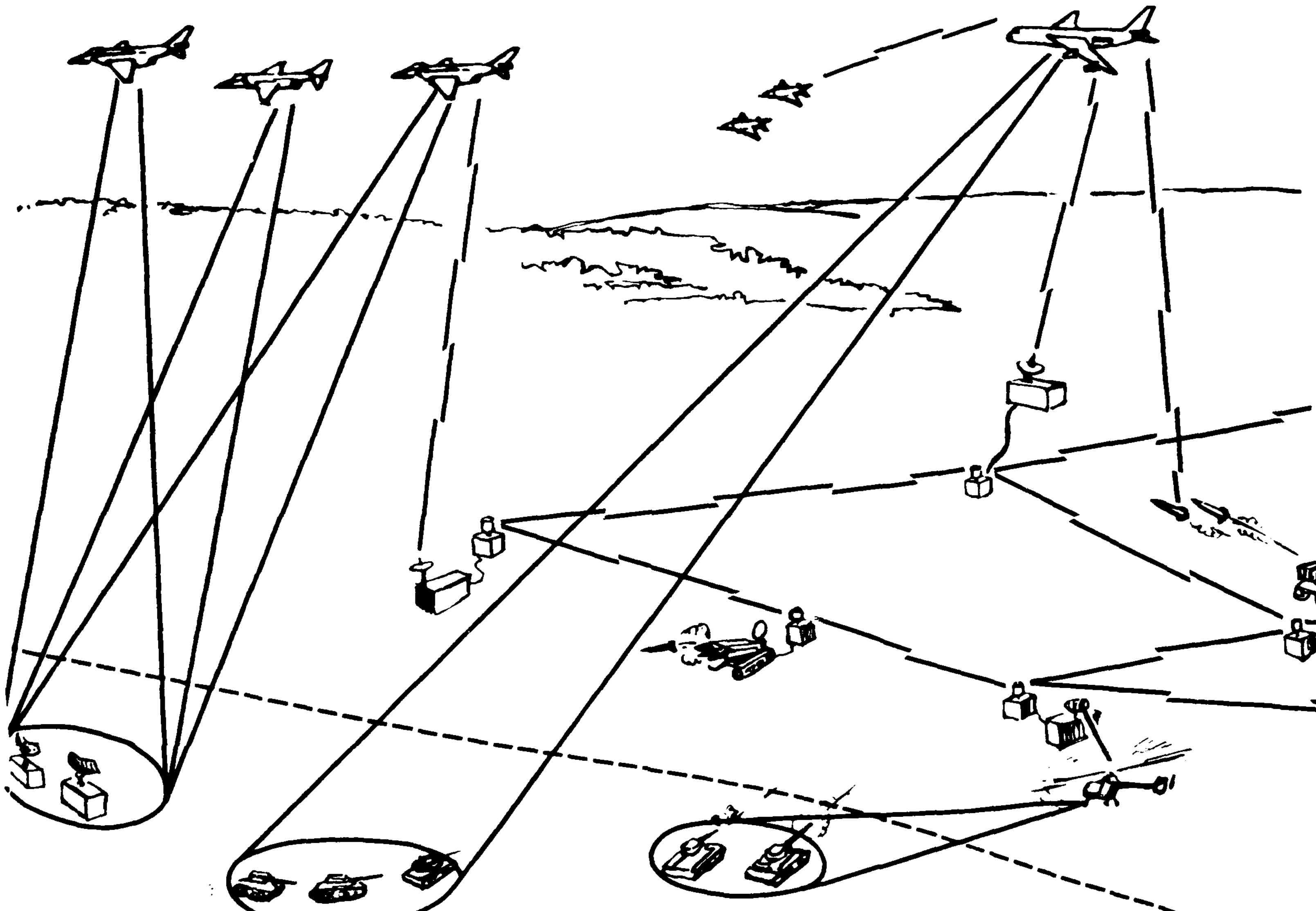

FIGURE 7. HIGHLY DISTRIBUTED SURFACE SURVEILLANCE AND IDENTIFICATION

(b) In the Highly Distributed concept, the force management function is performed by a distributed system composed of small, mobile elements as in figure 8. Each element is self-contained, carries its own power supply, and is modularized to enable flexibility of employment and facilitiate systems improvements. Distributing the force management functions among physically separated elements and providing for redundancy by flexible assignment of back-ups enables the force management function to absorb losses and, at the same time, denies the enemy confidence in a selective counter C^2 attack. Primary and back-up systems are kept up-to-date by distributing information as soon as it is entered into the system. Functional modularity, redundancy, and the ability of an element to shift functions allows essential tasks to be maintained even in the event of major system losses. All elements of the theater C^2 system are tied together through the utility communications network described in paragraph 4-3c(3). Interface with the communications network is via fiber optics or short range millimeter-wave. Disassociating the main functional elements from identifying communications elements makes them more difficult to detect. These features increase survivability, provide a capability for graceful degradation, increase system flexibility, and enhance command succession or change of location.

4-4. <u>Distributed Concept</u>.

a. Surge and Build-up Phases. In the surge and build-up phases, the operation of the Distributed TACS is no different from that described for the Highly Distributed TACS (paragraph 4-3a and 4-3b). During the surge phase, the deployable TACS consists of an airborne capability with remote support. The build-up phase sees the TACS transition from an airborne to a primarily surface based capability.

b. Sustained phase.

(1) Like the Highly Distributed concept, the Distributed concept relies upon distribution of C^2 functions (although not to the same extent), physical separation of elements, and flexibility

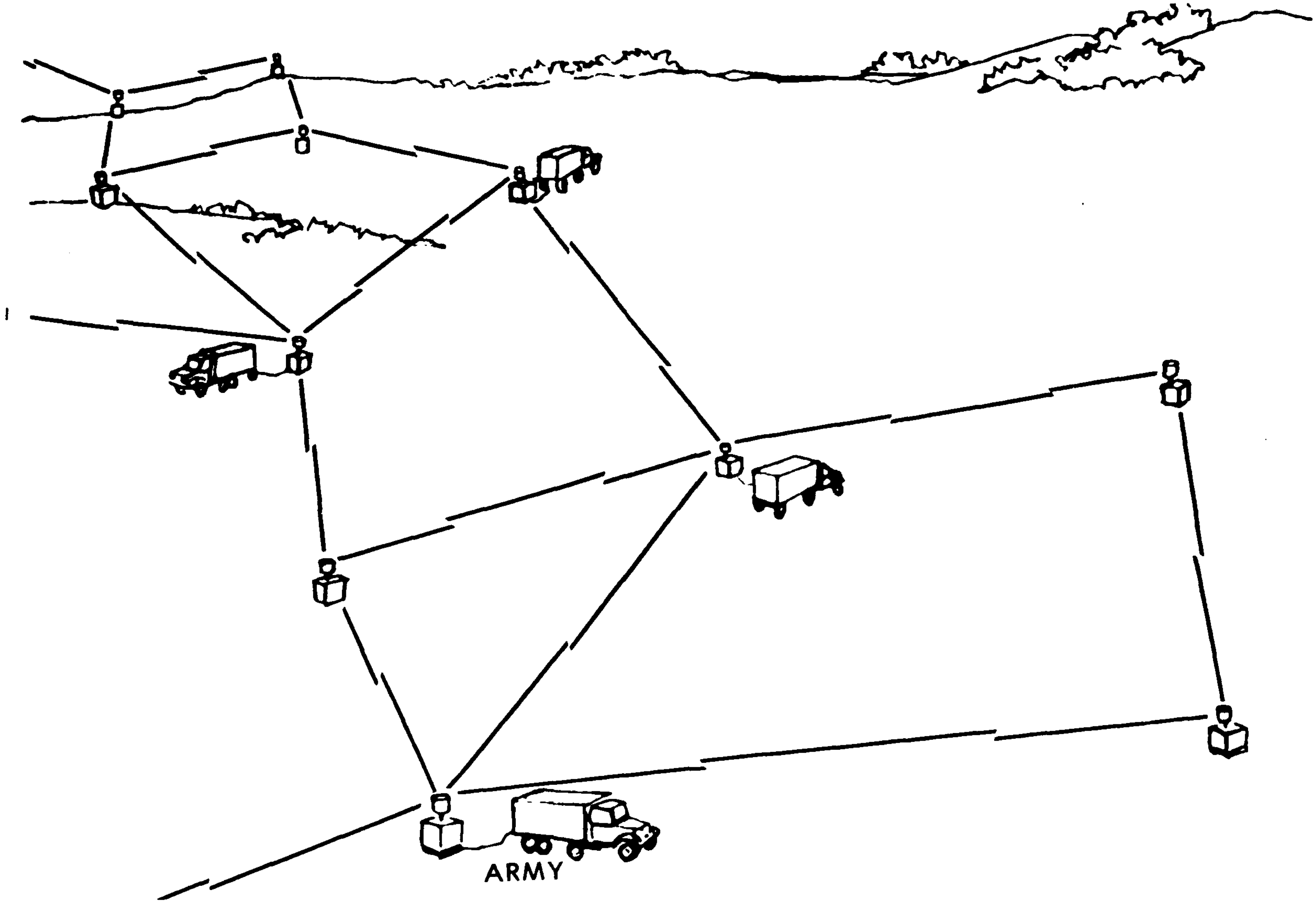

FIGURE 8. HIGHLY DISTRIBUTED FORCE MANAGEMENT

to reduce the effects of enemy action. However, it assumes there will be locations within the theater that will be relatively safe from the enemy's weaponry. The primary differences between the Highly Distributed and the Distributed concepts lie in the air surveillance and communications activities.

(2) Figure 9 depicts a portion of the Distributed deployable TACS in operation. In contrast to the Highly Distributed system, it is an autonomous Air Force operation although it uses available information provided by joint services. Like the Highly Distributed concept, vehicle-mounted elements carry their own power and permit great mobility and rapid deployment. Elements are separated by distances as dictated by the threat. In low threat areas, they may be clustered for convenience while in higher threat areas, they are dispersed so they must be individually targeted by the enemy even if he uses nuclear or CB weapons.

(3) Communications.

(a) Distributed operations facilities are connected by mobile communications elements which can serve more than one user and have a multiple link capability. In figure 10, the communications element in the center foreground is maintaining line-of-sight (LOS) links to another communications element and to an airborne relay and conventional troposcatter links to joint forces in the foward areas and to adjacent Air Force units. Not shown are local area communications (fiber optics, millimeter-wave or wire) to using C^2 elements. Communications survivability is enhanced by the use of multiple, encrypted, highly jam-resistant links. For those forward links to the weapon systems and front line operators, airborne relays in addition to conventional HF or troposcatter, are used. For inter theater communications in areas removed from the high threat area, existing types of links will be used. Satellite communications, fiber optics, UHF, VHF, HF, troposcatter, and wire all play their part where needed. Communications out of the theater rely heavily on satellites, HF, and land lines if available.

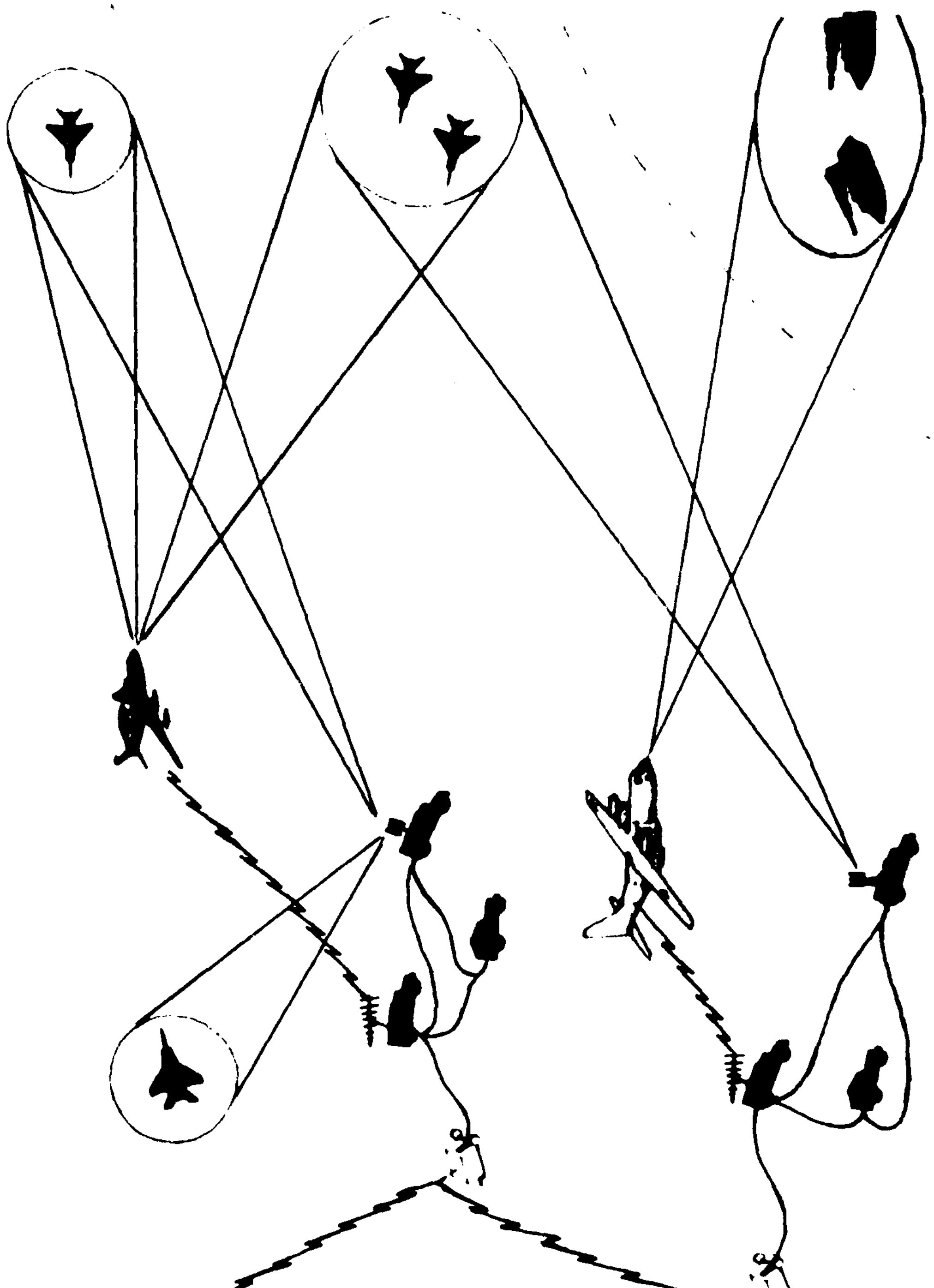

FIGURE 9. DISTRIBUTED CONCEPT

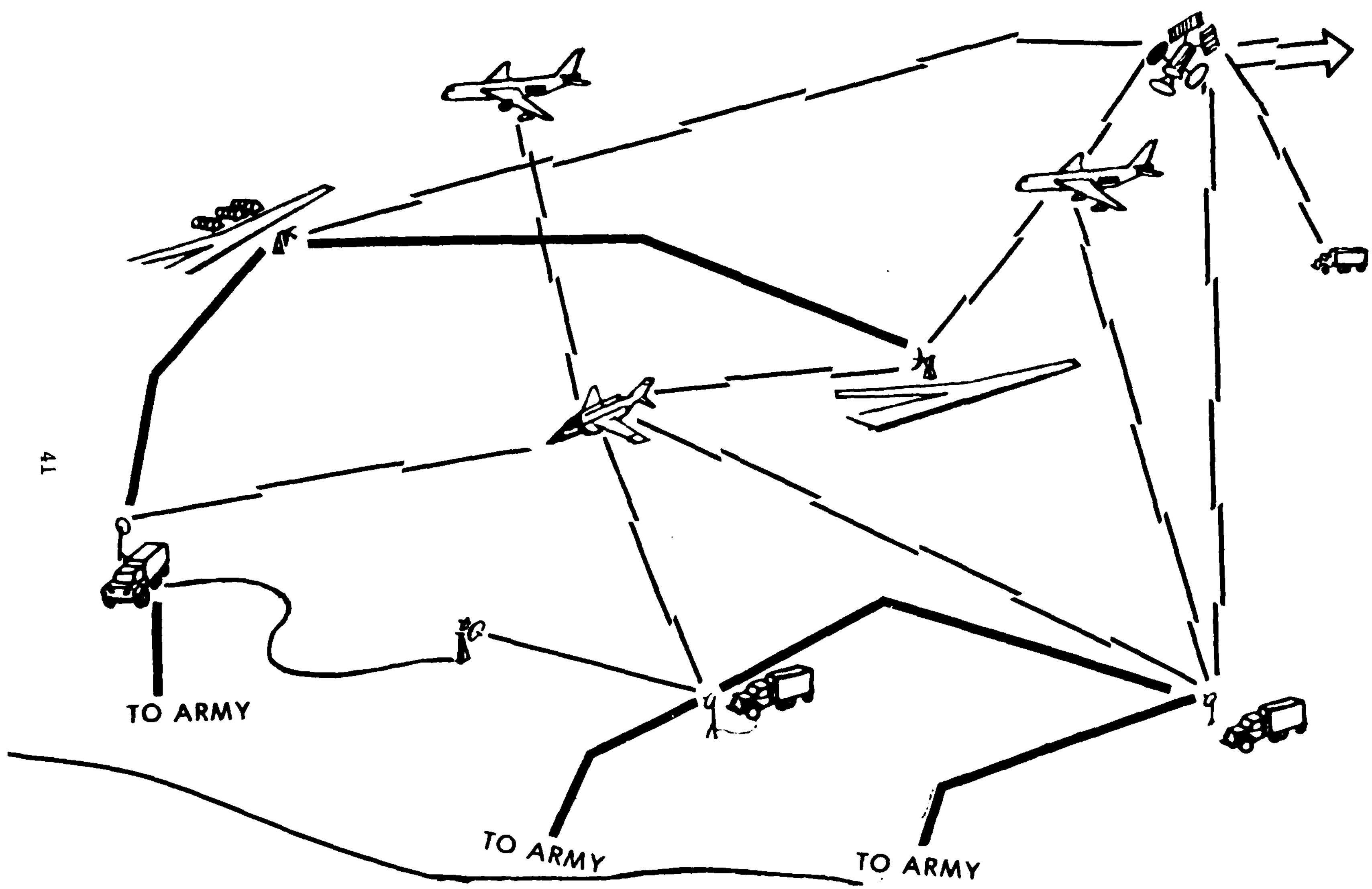

FIGURE 10. DISTRIBUTED COMMUNICATIONS

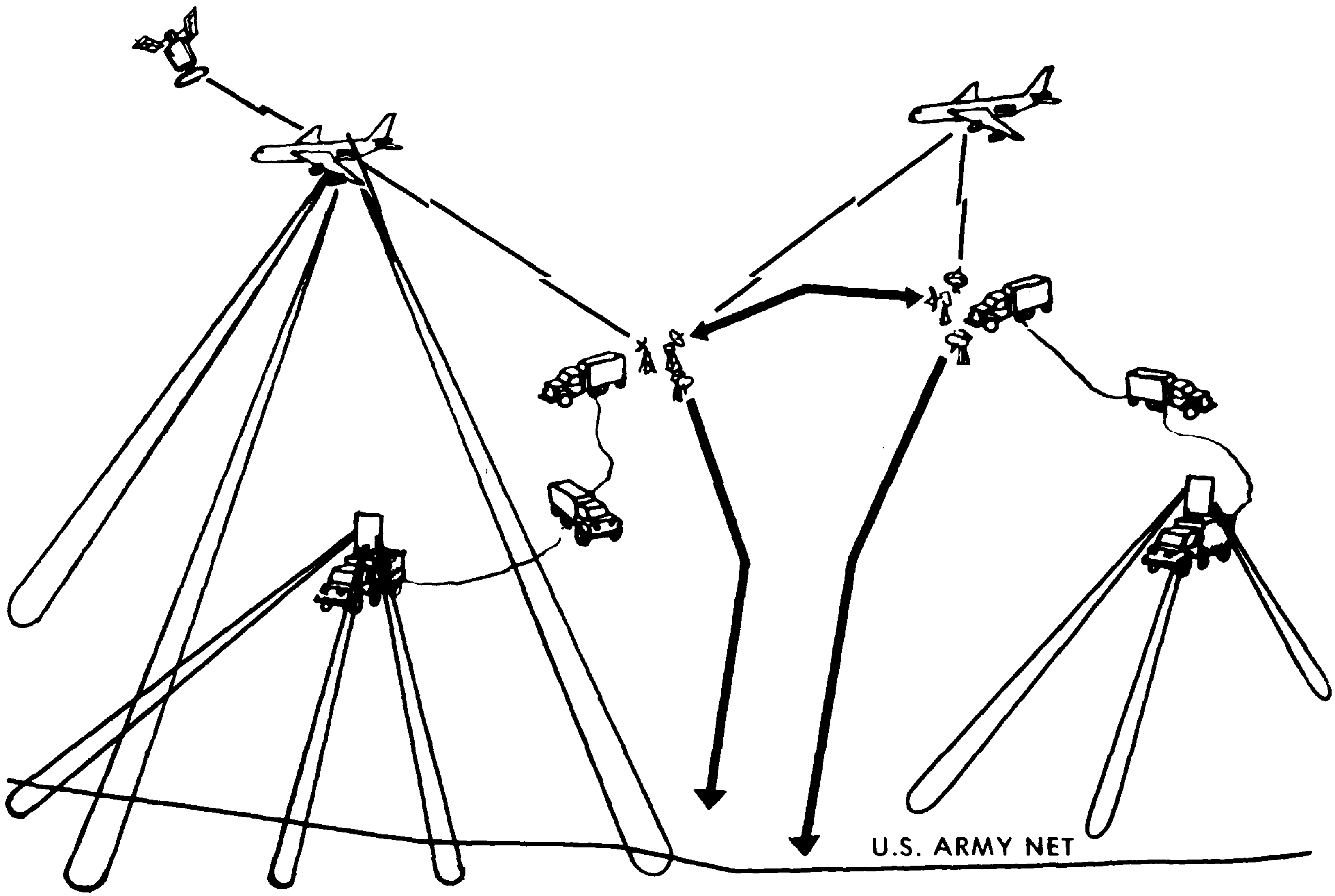

FIGURE 11. DISTRIBUTED AIR SURVEILLANCE, AIR IDENTIFICATION, AND AIRSPACE CONTROL

(b) The Distributed communications network is an upgrade of present capabilities with more mobility, redundancy, and ECM resistance. However, it remains a point-to-point system whose elements betray the location and function of the command and control elements they serve. The unilateral Air Force aspect of this concept limits the number of communications elements which can be made available.

(4) Air Surveillance and Identification and Airspace Control. As in the previous concept, the air surveillance picture is developed by netting individual sensors. The users of air surveillance information are supplied with data displays tailored to their needs (for example: functional, geographic, or both). Unlike the previous concept, the Distributed system relies on long range radars and airborne sensors to develop the air situation picture. The long range radars are truck mounted, self contained, and have a maximum electronic counter countermeasures (ECCM) capability. The airborne sensors provide low altitude coverage of the forward areas that connot be covered by the long range radars due to the earth's curvature and terrain masking. Figure 11 shows two truck mounted radars in operation. The radars are connected into the theater net through the communications vehicles shown. Also depicted are two vehicles containing operators using air surveillance information derived from the net for warning and airspace control.

(5) Surface Surveillance and Identification. Surface surveillance and identification are done in an analogous manner to air surveillance and identification. The primary difference between surface surveillance and identification in this concept and that of the highly distributed concept is that here the surface surveillance and identification network is an Air Force rather than a joint asset. Information is supplied to the net via Air Force sensors only. However, processed information from the net is exchanged with joint services. A portion of the Distributed surface surveillance network is shown in figure 12. Individual sensors are tied into the network via the mobile communications elements.

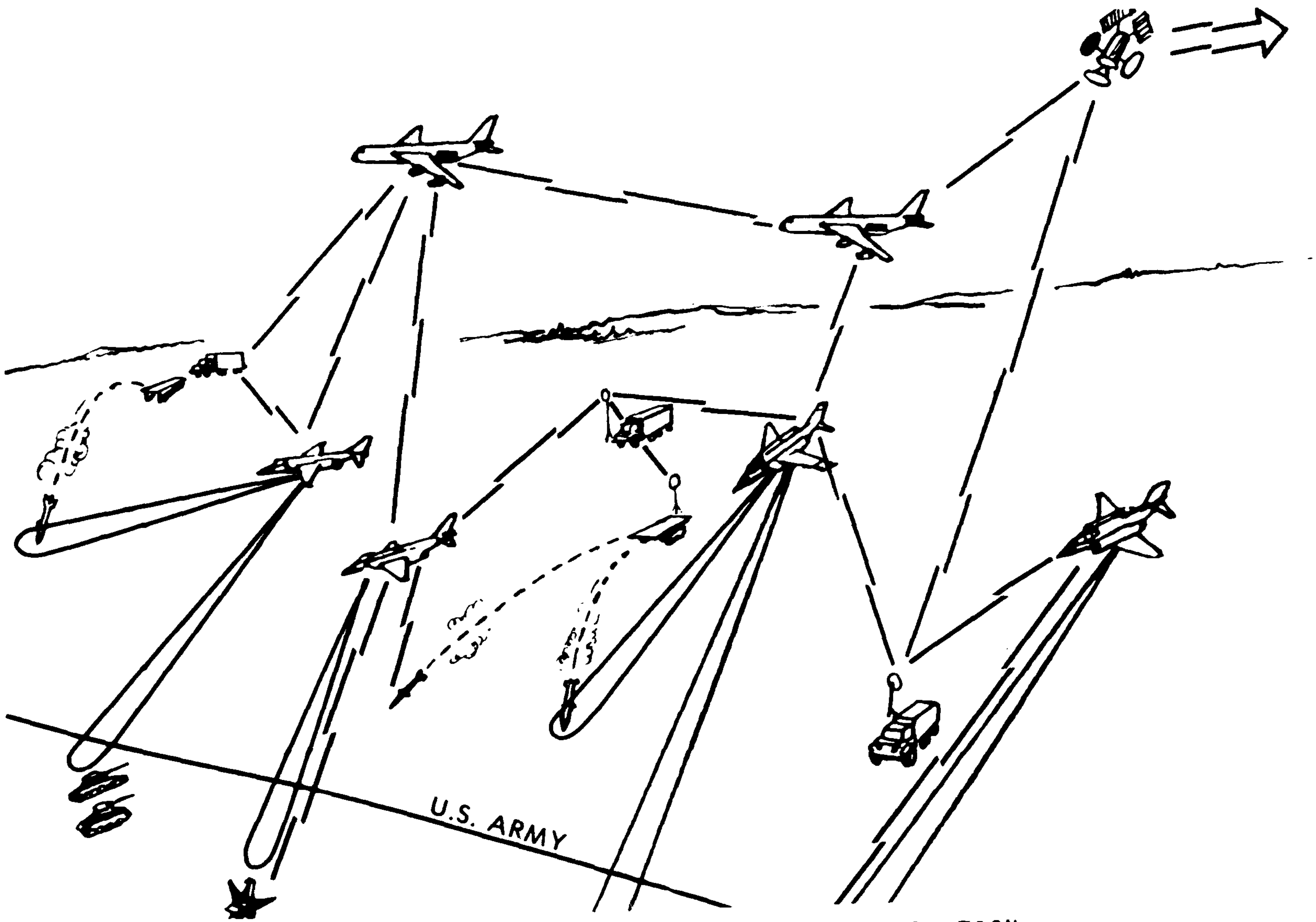

FIGURE 12. DISTRIBUTED SURFACE SURVEILLANCE AND IDENTIFIC.TION

(6) Force Management. The distributed force management system itself is similar to the Highly Distributed system. Figure 13 depicts the Distributed force management system.

4-5. Semi-distributed Concept.

a. Surge and Build-up Phases. In the surge phase, the Semi-distributed concept is an airborne capability identicial to that described in paragraph 4-3a. Transition between the surge and sustained phases is accomplished as described in paragraph 4-3b.

b. Sustained Phase.

(1) As the name implies, the Semi-distributed concept is less distributed than the preceding concepts. Like the Distributed concept, it assumes there will be locations within the theater which are largely safe from enemy weaponry. In the Semi-distributed concept, structures and functions are dispersed in shelters over some local geographic area, such as in the vicinity of an airbase. Each shelter is separated from the others by a great enough distance so each must be individually targeted by the enemy using conventional weapons. One such cluster of shelters is depicted in figure 14. Shelters are readily transportable, although not necessarily self propelled, and incorporate integral CBR protection. Because of the concentration of elements and shelters into local area groupings, the Semi-distributed TACS must be far removed from areas of concentrated enemy action for survivability.

(2) As in the Distributed concept, the air surveillance picture is developed mostly from airborne sensors and supplemented by long range radars. Surface surveillance is primarily accomplished by airborne sensors. Each shelter is connected within the cluster by a local area communications net. Clusters are in turn linked together by the theater communications network. The Semi-distributed system would exchange processed information with joint service and allied systems.

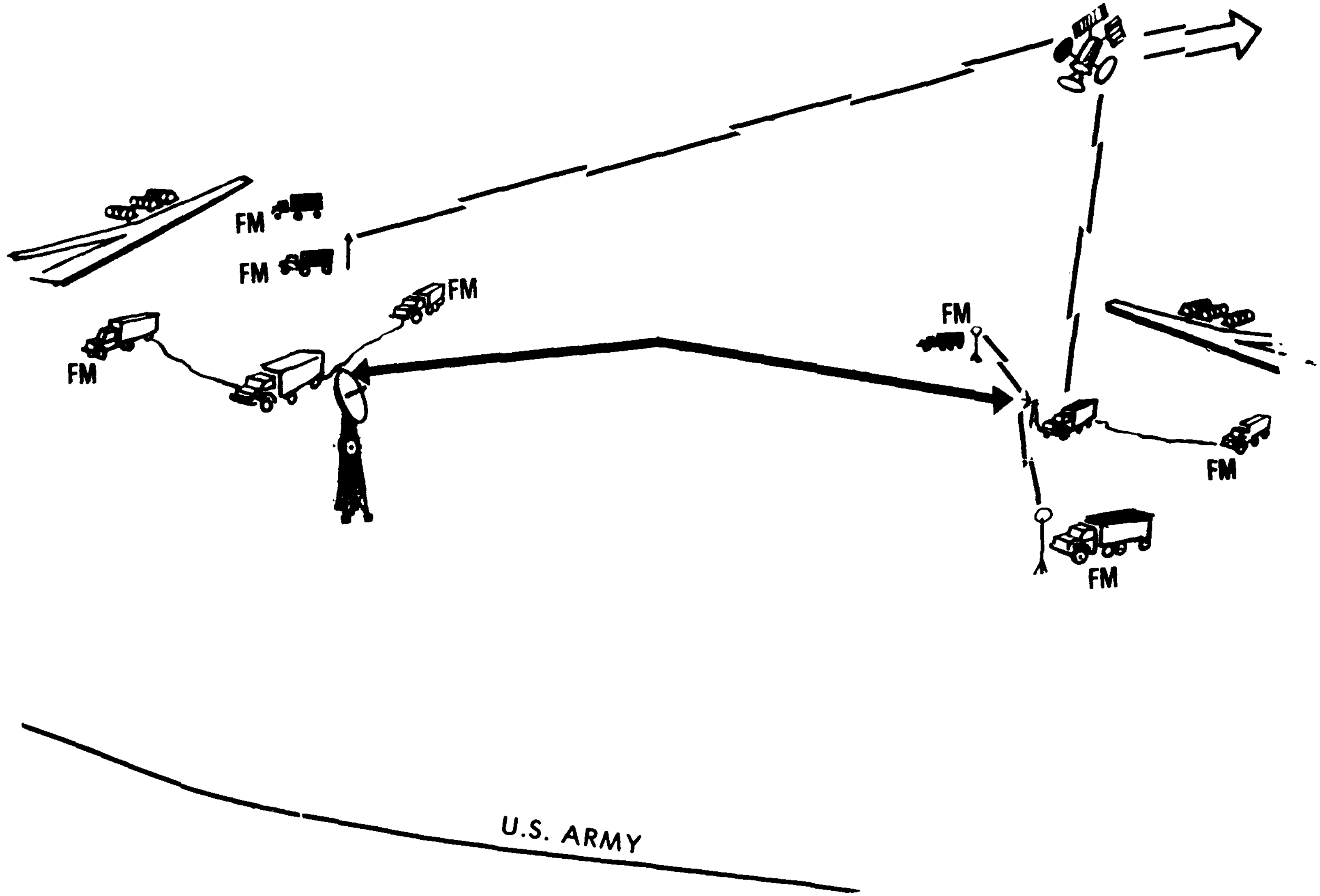

FIGURE 13. DISTRIBUTED FORCE MANAGEMENT

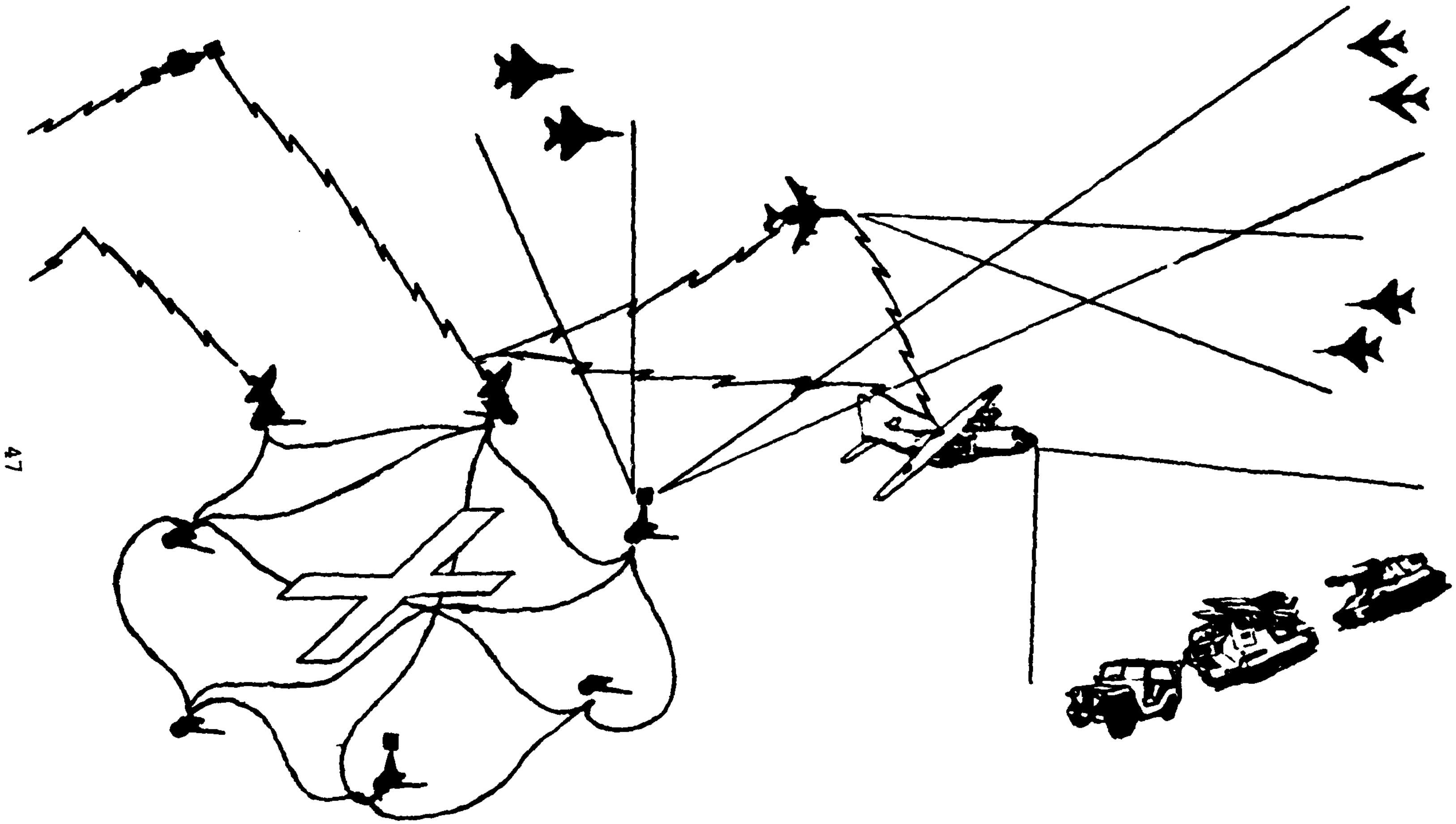

FIGURE 14. SEMI-DISTRIBUTED CONCEPT

(3) Communications. As shown in Figure 15, intra cluster communications links connect the dispersed elements within the cluster. Fiber optics, millimeter-wave, or wire are used to provide a secure and redundant network. Inter cluster communications are provided by a variety of modes including troposcatter, SATCOM, HF, VHF, UHF, or airborne relay. Survivability of these point-to-point communications is increased by redundancy. The specific type of link used for out of theater communications depends on location, electronic and physical threat, and amount of traffic. Satellite communications or land lines, with HF as a limited back-up, are employed as in the other concepts. Because the elements of the Semi-distributed system are removed as far as possible from the battle area, communications forward to the weapons and sensor systems presents a major challenge. The use of airborne relays, HF, UHF, and data links with adaptive antennas and advanced ECCM techniques are mandatory.

(4) Air Surveillance and Identification and Airspace Control. The air surveillance and identification and airspace control activities use the same sensor network as in the Distributed concept. As shown in figure 16, air surveillance coverage of the forward areas relies on the use of airborne sensors supplemented by long range radars from the vicinity of the clusters. In areas of intense threat, the clusters will be removed from the action for survivability. Therefore, heavy reliance is placed on the airborne sensors and the information provided by joint services for developing an air situation picture over the battle area.

(5) Surface Surveillance and Identification. This network depicted in figure 17, is the same as in the previous concept.

(6) Force Management. The force management function is performed in the same manner as it is today, except force management personnel are physically dispersed and key people separated to prevent single shot destruction of a major portion of the command structure. As in the other concepts, force mangement processes are automated to increase the timeliness and accuracy of

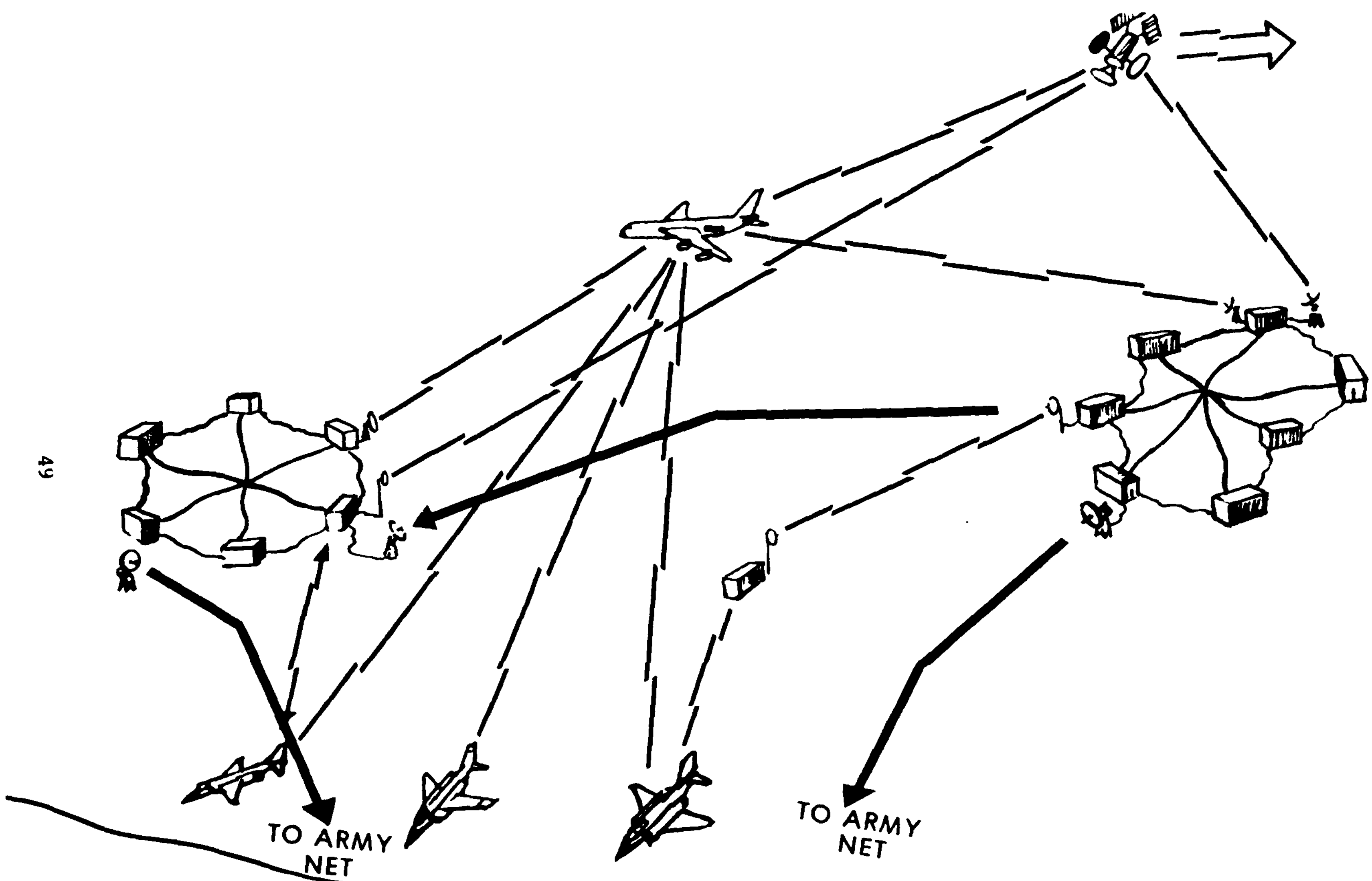

FIGURE 15. SEMI-DISTRIBUTED COMMUNICATIONS

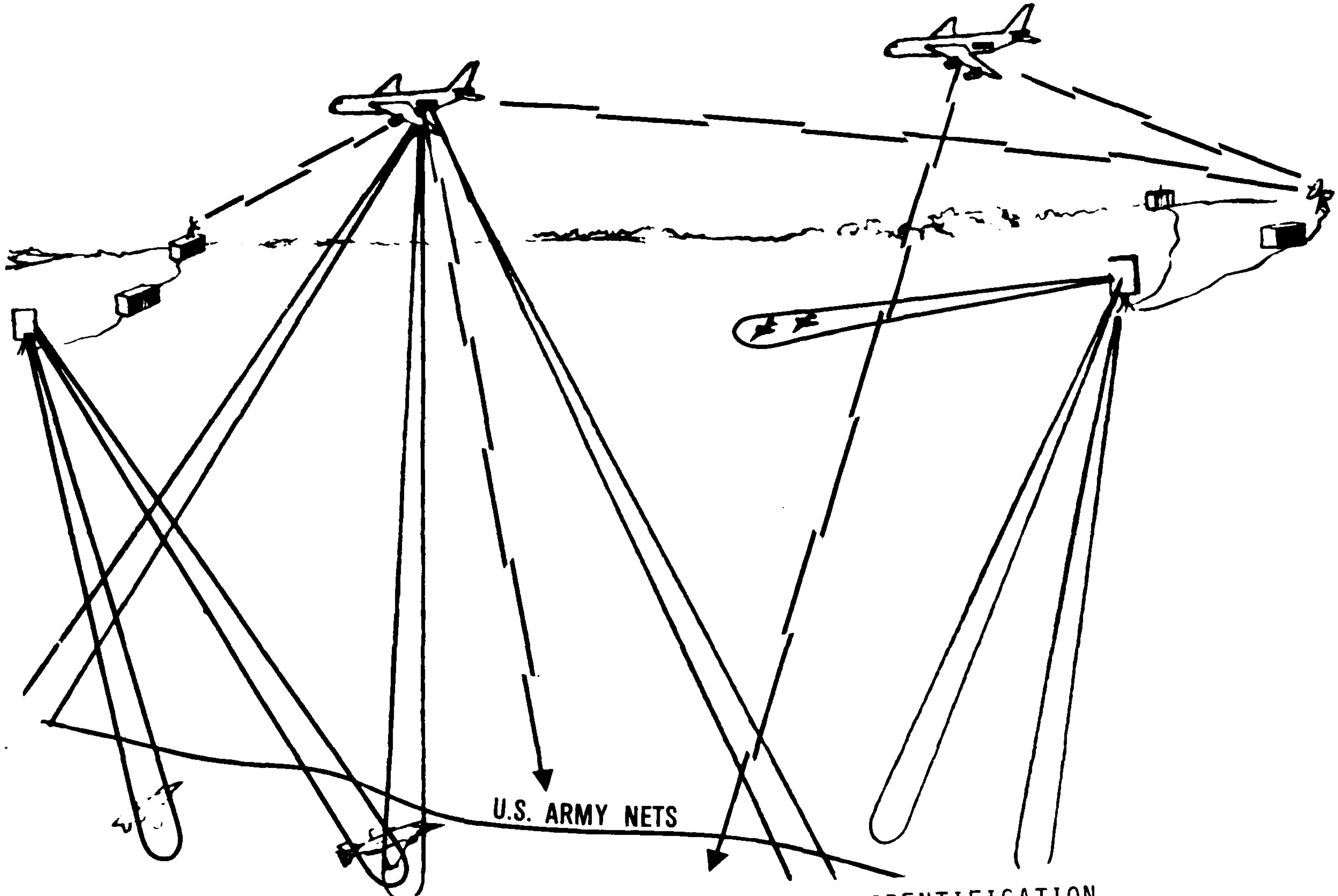

FIGURE 16. SEMI-DISTRIBUTED AIR SURVEILLANCE, AIR IDENTIFICATION, AND AIRSPACE CONTROL

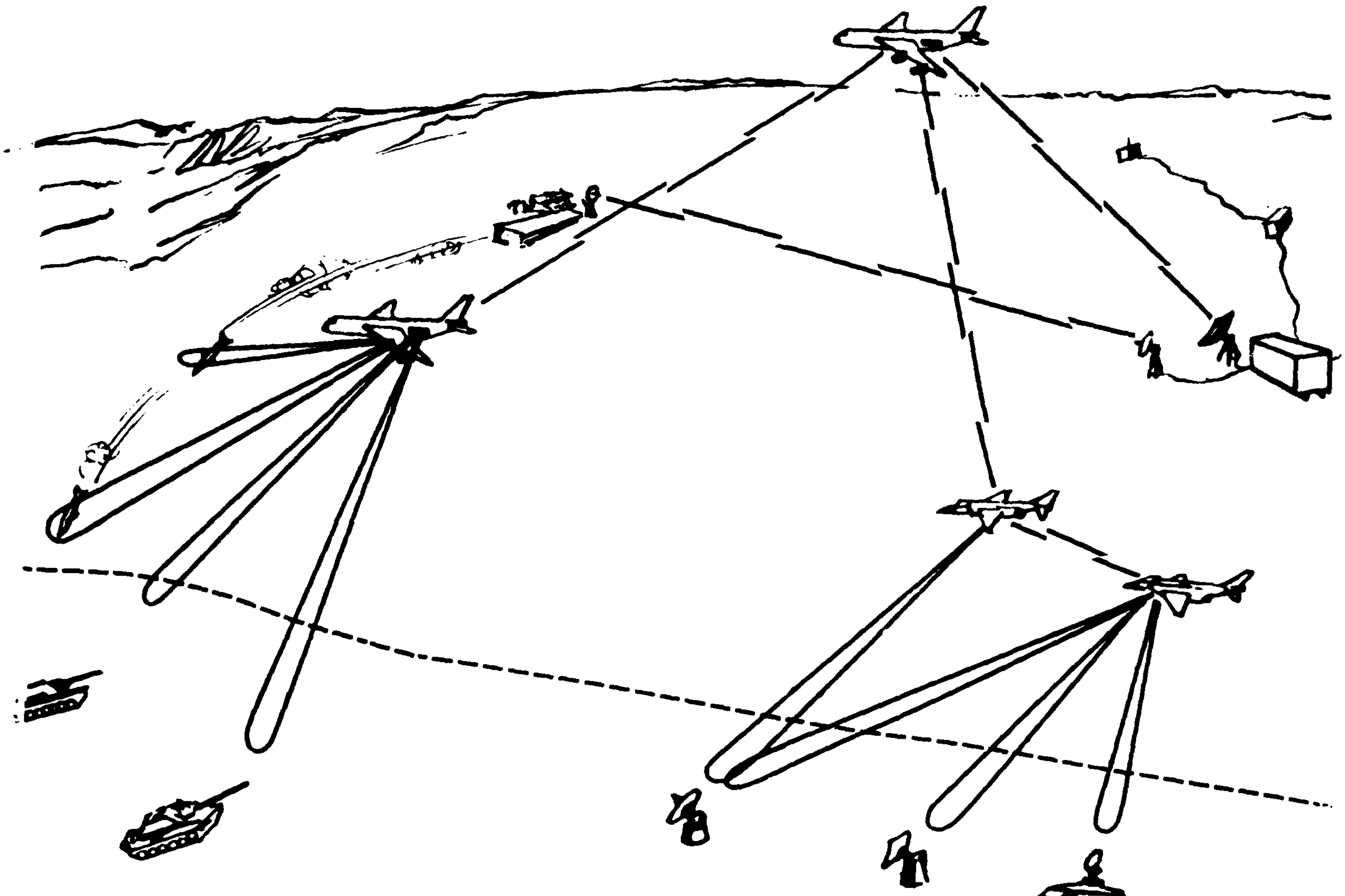

FIGURE 17. SEMI-DISTRIBUTED SURFACE SURVEILLANCE AND IDENTIFICATION

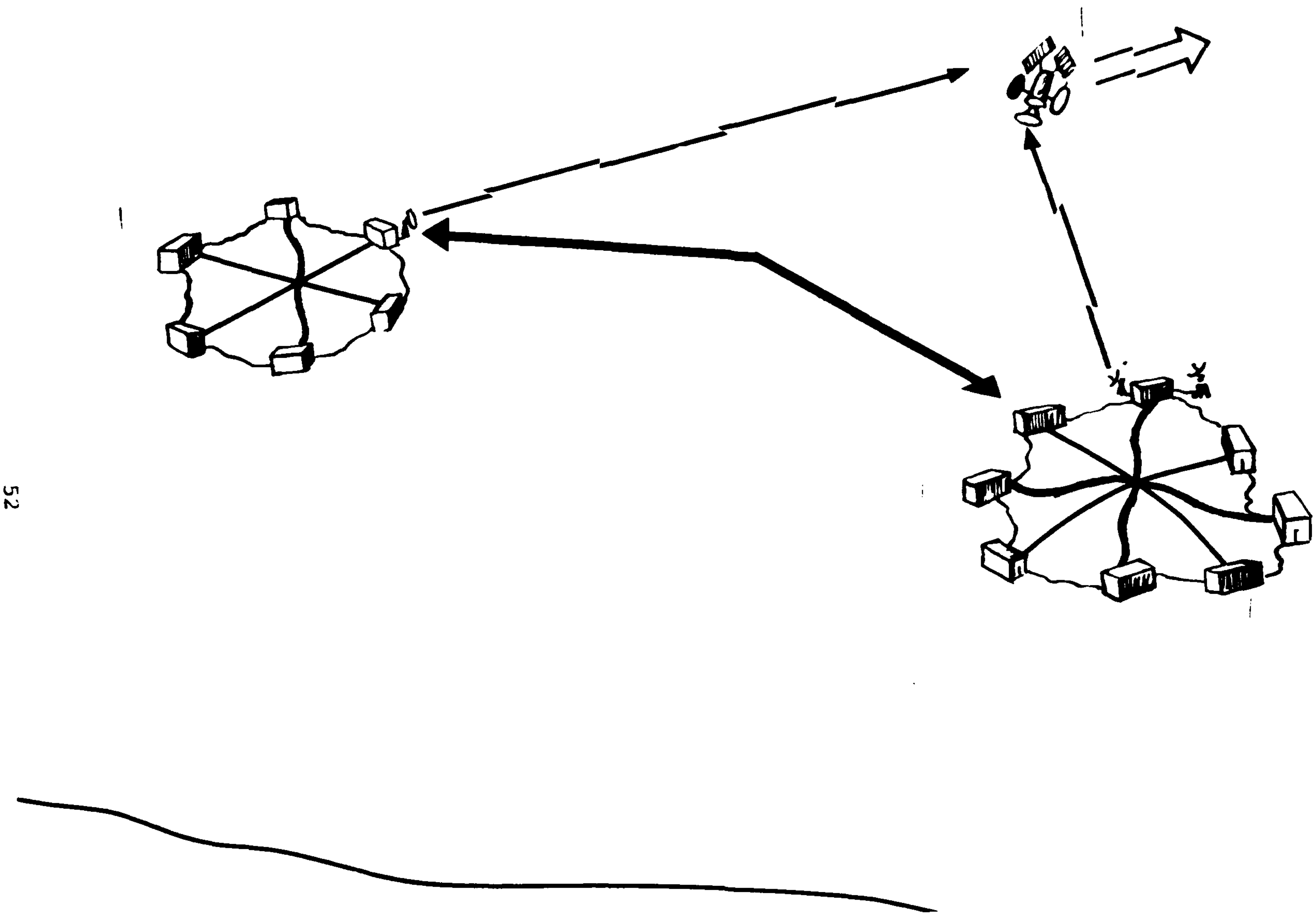

FIGURE 18. SEMI-DISTRIBUTED FORCE MANAGEMENT

the decision and command function. Configuration of the force management system is shown in figure 18.

4-6. Airship Concept.

a. During the sustained phase of warfare under the airship concept, shown in figure 19, all deployable TACS elements are located in high altitude (25K-30K meters) rigid balloons stationed hundreds of kilometers from the front. These balloon-mounted elements move under their own power to the theater of operations during the build-up phase. The surge phase of the airship concept is the same as the surge phase of the distributed concepts described in paragraph 4-3a.

b. Mounting TACS capabilities on airships facilitates deployments and permits long time on station. The airship TACS operates above most weather. The airships are large, keeping physical and functional distribution to a minimum. Sensors for air and surface surveillance and identification are mounted on the balloons and supplemented by airborne radars. Force management and airspace control activities are accomplished by personnel on-board the airships. In addition, some functions are accomplished remotely. The TACS is tied together by an intra fleet secure, jam-resistant laser, extremely high frequency (EHF), or super high frequency (SHF) communications network.

4-7. Remote Concept.

In the remote concept, the majority of TACS activities are accomplished out of the theater during all phases of warfare. The only TACS elements located within the theater are the air and surface surveillance sensors themselves. Sensor information is transmitted from the theater via satellite, other communications repeaters, or cable to the remote TACS facility (which is either permanently located in the US or in several facilities located in relatively secure areas worldwide). All force management, airspace control, and sensor management activities are located in these facilities. Instructions are relayed back into the theater to the

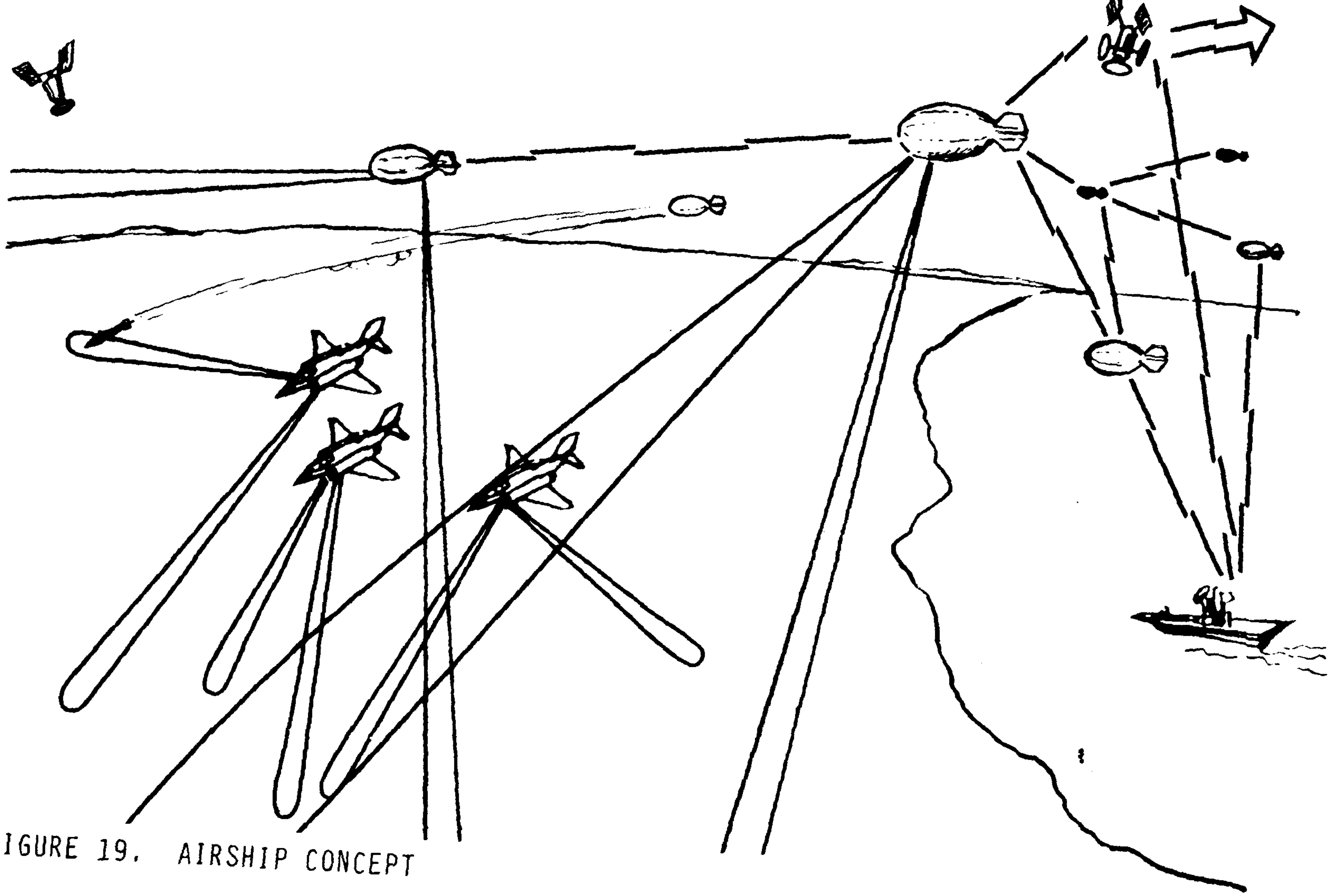

FIGURE 19. AIRSHIP CONCEPT

deployed weapons and sensor systems. The viability of this concept is largely dependent on assured, long range communications. The remote concept is shown in figure 20.

4-8. Airframe Dependent Concept.

Figure 21 depicts the airframe dependent concept. In this concept, deployable TACS elements are located on-board dedicated aircraft. Surge phase operations are identical to those described in para 4-3a. Once airfields have been secured, the airframe mounted elements of the TACS operate primarily on the ground, from parking ramps on airfields. The capability to return to airborne operations exists should the threat dictate. Air and surface surveillance activities rely on airborne sensors to provide the necessary coverage. Force mangement and airspace control stations are located on the airframes as well. Communications tying the system together are the same as described in paragraph 4-5b(3).

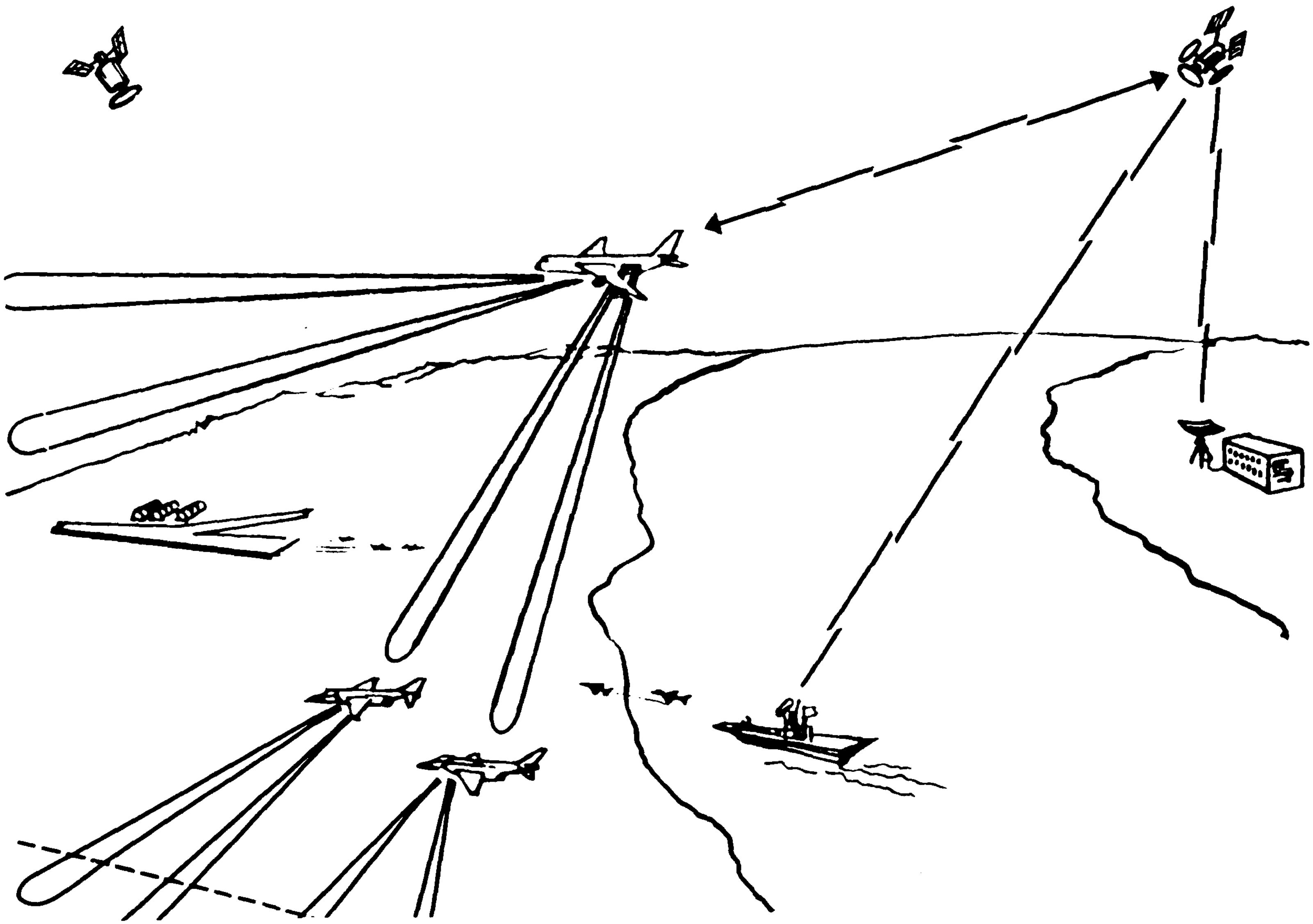

FIGURE 20. REMOTE CONCEPT

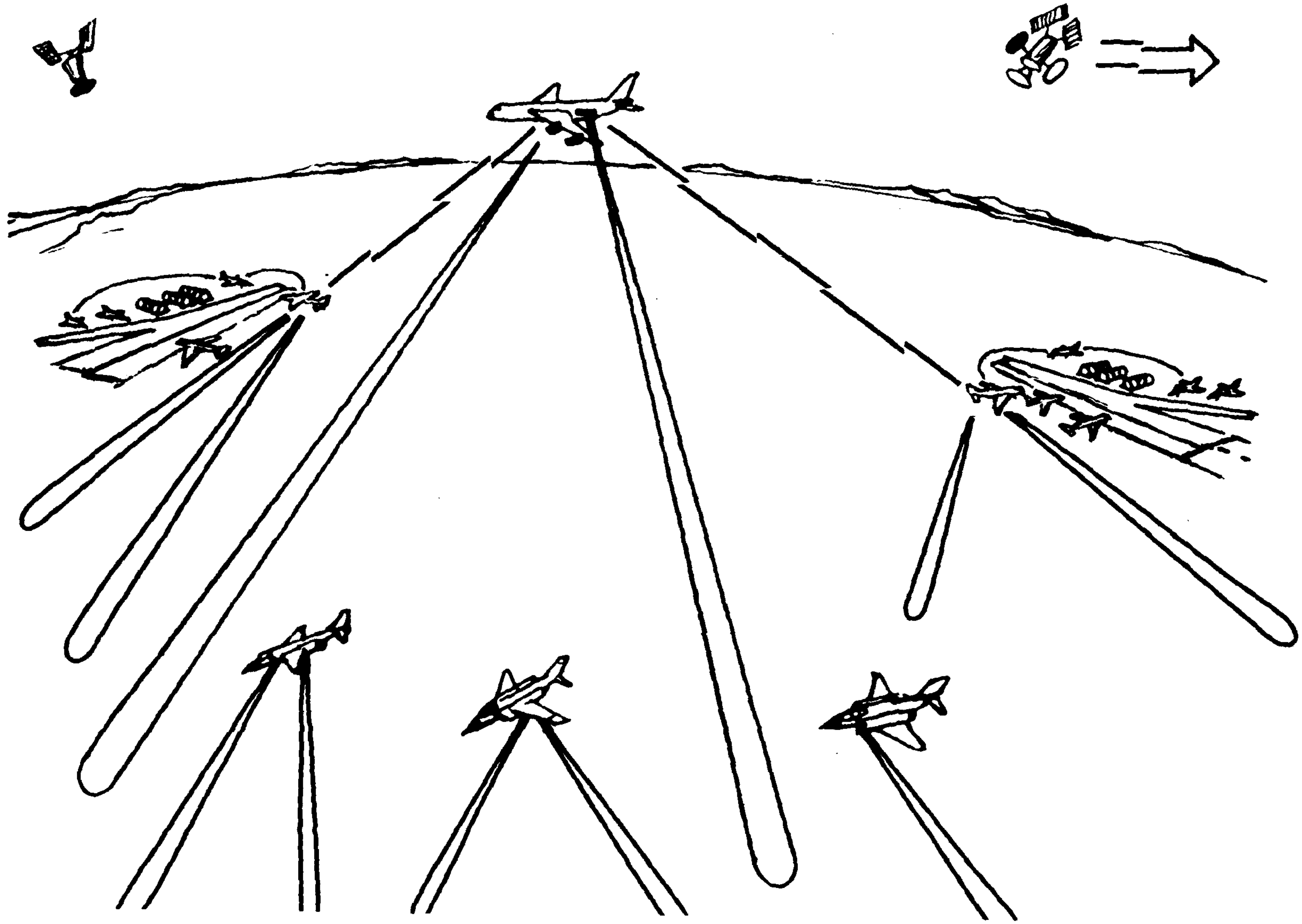

FIGURE 21. AIRFRAME DEPENDENT CONCEPT

TABLE 1 CONCEPT EVALUATION*

Concept	Physical Survivability		Chem, Bio, and Rad Survivability								
	Gen War	Insur-gency	CB	R	Elect Surv	Grace Deg	All Env Ops	Mob	Deploy	Flex	Support
Highly Distributed	10	7	8	10	10	10	6	8	6	10	4
Distributed	8	7	8	10	9	9	7	8	7	9	6
Semi-Distributed	5	6	8	8	6	8	4	4	8	6	8
Airship	4	10	10	UNK	7	4	10	10	9	2	10
Remote	3	6	9	10	2	2	**	**	**	**	7
Airframe Dependent	3	5	8	3	5	5	2	2	10	2	10

* Ten must scoring: A scale of 10 decreasing to 1 with best concept in each column receiving score of 10.

** Depends on sensor concept employed.

5. CONCEPT EVALUATION

5-1. Introduction.

The concept evaluation considers the technical feasibility of each concept and how well each satisfies the goals presented in Section 3. The most promising concepts are recommended for further pursuit. All concepts are believed to be technically feasible by the year 2000 timeframe with the exception of the Airship concept. Its feasibility is questionable. There is no known effort underway at the present which looks at the means for lifting heavy payloads to very high altitudes using Airships. Technical risk associated with the distributed concepts increases with the degree of distribution. Cost implications of the alternative concepts were not assessed.

5-2. Assessment.

A subjective assessment of how well the concepts described in the previous section meet the goals of Section 3 is presented in table 1. A "ten must" evaluation scheme is used where, for each goal, the concept that comes closest to meeting the goals is given a score of ten. Other concepts which meet the goal less well score lower on a scale of 10 to 1. The score presented at each concept-goal intersection of table 1, represents an evaluation of the concept against the specified goal during the sustained phase of warfare (with warfare intensities ranging from insurgency to theater conventional through theater nuclear warfare). The surge phase of each concept is essentially the same (an airborne capability). The build-up phase was not evaluated due to time constraints. Evaluation of the goals of reliability, maintainability, and interoperability requires a level of detail not presently available in the concepts. Therefore, these goals do not appear in table 1. The following paragraphs present specific comments concerning the evaluation of each concept dealing primarily with survivability in the high threat environment.

5-3. Surge Phase, All Concepts.

The maneuverability of the TACS airborne elements provides some measure of protection. Fighter cover may be used to increase the physical survivability. Individual airborne radars will be easily located by the enemy and jammed or attacked depending on enemy capabilities. The number of airborne elements required to assure survivability of the capability is dependent on the specific threat. Friendly airbases are required within a reasonable range to support this airborne capability.

5-4. Sustained Phase.

a. Highly Distributed Concept.

(1) The Highly Distributed concept was developed to assure survivability of command and control in the face of an intense enemy threat. When coping with lesser threats, deployable TACS elements may safely operate closer together. As an example: in countering an insurgency, force managment elements might be parked together in a group for convenience.

(2) Survivability of the communications system and, to a certain extent, the surveillance systems (both are composed of emitting elements), is enhanced by the unique nature of the utility communications system, the number of emitters, and by the ability to "hide in the crowd". Emitters should be alike. The greater the number of emitters, the more survivable the system. Therefore, joint deployment of like equipment enhances system survivability. Conversely, unless there is joint service participation in the acquisition and operation of the Highly Distributed communications equipment and compatible surveillance sensors, the full capabilities of this concept connot be realized.

b. Distributed Concept. The Distributed concept assumes the deployable TACS will have the option of standing off from an intense threat, and that areas safe enough for its type of operations will exist within the theater. Airborne sensors will be

lucrative targets for the enemy. Unless their survivability can be enhanced through technology and self-protection systems, reliance on them for forward area coverage is questionable. The communications system is an advanced version of the point-to-point system available today and relies on redundancy of point-to-point links for survivability.

c. Semi-distributed Concept. As in the Distributed concept, the Semi-distributed TACS also assumes the ability to trade distance from the action for survivability and the existance of sanctuary within the theater. If it is within reach of enemy weaponry, the Semi-distributed system is the most vulnerable of the distributed concepts. Its viability in tactical nuclear warfare is questionable at best. If the enemy denies the use of airborne sensors, air surveillance coverage of the forward areas will be greatly degraded and become primarily an Army function. Long-range radars alone will not cover the lower altitudes due to terrain masking and the earth's curvature.

d. Airship Concept. Physical survivability of the Airship concept in sustained general warfare scores poorly. Limited numbers and maneuverability combined with large size and detectability reduce the survivability of the Airship concept.

e. Remote Concept. The Remote concept relies on satellites or cable, with HF as a very limited back-up, to connect the TACS activities at the remote locations with the sensors and weapons systems within the theater. This communications thread out of the theater is vulnerable to disruption by physical attack or electronic means. Either can be mounted by a sophisticated enemy. Thus, to rely on it for providing the total TACS services is risky. However, as a feature of more comprehensive concepts, remoting certainly has applications for selected functions.

f. Airframe Dependent Concept. In addition to being housed in soft high value assets (aircraft), the Airframe Dependent concept suffers from the same vulnerabilities as the Semi-distributed concept when operating in its sustained mode

(parked on airfields). Because of limited sustainability, capacity, and supportability, the ability to maintain a totally airborne TACS capability for certain periods and in certain areas does little to contribute to the survivability of this concept during prolonged large scale warfare against a major enemy.

g. Although increased survivability is a feature of all three distributed concepts, it is a matter of degree with the Highly Distributed being the most survivable in high threat areas. As pure concepts, the Remote and Airframe Dependent do not demonstrate improved survivability. However, some features of these concepts are useful for incorporation within the distributed systems. The limited survivability of the Airship concept in any large scale warfare and the question of its technological feasibility negates it as a candidate for further study.

6. TECHNOLOGY ASSESSMENT

6-1. Introduction.

This section highlights TACS-2000 desired capabilities and solutions for implementing those capabilities and assesses the degree to which the capabilities and solutions are supported by known technology programs. The set of capabilities and solutions presented here is not exhaustive but represents what are considered to be the more essential subjects. A set of capabilities appropriate to all distributed concepts and phases of warfare are presented first in paragraph 6-3: General Capabilities, All Distributed Concepts. Thereafter, each activity area is described in terms of desired capabilities and possible solutions for the surge and sustained phases of the Highly Distributed, Distributed, and Semi-distributed concepts.

6-2. Annotation.

Current technology programs have been subjectively evaluated to determine how well they support capabilities and solutions for each concept. The list has been annotated in the following manner:

(A) An adequate technology program exists to accomplish the desired capability or solution.

(P) Only partial solutions for TACS-2000 appear to be offered by the known programs addressing the capability or solution.

(N) There are no known programs of consequence addressing the capabilities or solutions for TACS-2000.

6-3. General Capabilities, All Distributed Concepts.

The following capabilities are applicable to all distributed concepts.

a. Provide methods for functional distribution and integration. (N)

b. Provide the means to support integrated operation of distributed functions. (P)

c. Provide sufficient automation to perform the functions at required rate and volume with minimum manpower. (P)

d. Provide methods for transitioning functions from one phase or mode (airborne, remote, ground) to another. (N)

e. Develop a unified information handling concept serving the total system which will provide for acceptance and integration of elements, subsystems and interfaces. (N)

f. Provide a system capability for continued operation in a CBR environment. The possibility of self-contained, autonomous operations for limited periods should be considered. (P)

6-4. Air Surveillance and Identification And Airspace Control.

a. Capabilities appropriate to all concepts and phases.

(1) Detection of small low altitude, low velocity targets against a clutter background and multipath environment. (A)

(2) Unambiguous tracking of highly maneuvering objects in a target rich environment. (P)

(3) Identification and classification of noncooperative targets. (P)

(4) Provide for the above capabilities while operating in a highly sophisticated electronic and physical threat environment. (P)

(5) Provide a surveillance system which exploits the synergistic effects of multiple sensors feeding and using a common net. (P)

b. Some solutions for the surge phase, all distributed concepts:

(1) Airborne sensors, netted together to provide fully automated tracking, possibility using remote "high flyers" close to the forward areas. (P)

(2) Controllers located in the sensor aircraft or in separated "control" aircraft depending on the size and intensity of the conflict. (A)

(3) High resolution short range sensors to provide warning of impending close-in attack leading to evasive action. (A)

(4) Adaptive waveforms. (P)

(5) Automatic beam forming control and waveform selection for the specific job to be done. (A)

c. Some solutions for the sustained phase, Highly Distributed concept:

(1) An integrated surveillance network which ties together data from all available sensors and provides information to all users anywhere in the net. (P)

(2) Contiguous coverage from redundant, low cost, possibly unmanned, sensor elements, having low altitude coverage with good subclutter rejection and small target detection capability. (N)

(3) Elevated antennas for greater coverage. (N)

d. Some solutions for the sustained phase, Distributed concept:

(1) Long-range highly jam resistant mobile ground radars for air surveillance, ID, and airspace control. (A)

(2) Netting of ground-based and airborne sensors for fully automated tracking. The radar signal or antenna could be used for the net communications. (A)

(3) Items 6-4b(4) and 6-4b(5) above apply to the ground radars.

e. Some solutions for the sustained phase, Semi-distributed concept: This concept has the same solution set as the Distributed concept except that the ground radars are only transportable. (A)

6-5. <u>Surface Surveillance and Identification</u>.

a. Capabilities appropriate to all concepts and phases.

(1) Detect, classify and identify surface targets and target systems. (A)

(2) Provide tracking of targets and target systems. (P)

(3) Provide the capability to use and manage multimedia sensors in a common system. (N)

(4) Provide a real time targeting data flow. (P)

(5) Provide survivability for the unique air and ground assets that make up the surface surveillance system. (P)

b. Some solutions in the surge phase, all distributed concepts:

(1) Multimedia sensor correlation for the detection, classification, ID, and tracking of targets. (N)

(2) Maximum onboard sensor processing to ease communications requirements and improve jam resistance. (P)

(3) Use of remotely piloted vehicles (RPVs) for sensor platforms. (P)

(4) Sensor management and exploitation and weapons control done from airborne platforms. (N)

(5) Directional data link antennas for signal protection between sensor platforms and user. (A)

c. Some solutions for the sustained phase, all distributed concepts:

(1) The solutions are the same as in the surge phase except that sensor management and weapons control is to be done from ground stations.

(2) The protection of the ground station is paramount. This can be accomplished by remoting, working through the "utility" communications net, point defense, locating outside the high threat area, or some combination of these. (P)

6-6. Force Management.

a. Capabilities appropriate to all concepts and phases.

(1) Provide software for user friendly man-machine interface, information exchange, applications support, and decision aids. (N)

(2) Maintain multiple and distributed data base content and time integrity, access control, and multilevel security. (P)

(3) Ensure automatic data distribution to users as the data becomes available. (N)

(4) Provide for acceptance of heterogeneous machines within the system. (P)

(5) Provide means for the control and supervision of the system. (N)

b. Some solutions for the surge phase, all distributed concepts:

(1) Essential critical data is carried onboard. The rest of the data and processing is done at a remote location. (N)

(2) Standardized functional modules which can be programmed for specific jobs. (N)

(3) Maximum automation of the onboard functions to reduce the number of people required. (N)

(4) Emphasize the use of fault tolerant systems. (P)

c. Some solutions for the sustained phase, all distributed concepts:

(1) Accomodate the hierarchical command structure while allowing flexibility for the relocation and reassignment of functional elements throughout the distributed system as required for survivability. (N)

(2) Maintain tailored data bases in the theater as needed to perform the mission and interface with remote data bases. (P)

(3) Elements are to be self-contained building blocks programmable for the required function or subfunction. (The degree of mobility varies with the concept). (N)

(4) Shelters that do not have uniquely identifiable signatures. (N)

6-7. <u>Communications</u>.

a. Capabilities appropriate to all concepts and phases.

(1) Provide assured communications (voice and data) for airborne operations, to and among forward weapons or sensors and control elements in a hostile environment. (A)

(2) Provide netted user communications (voice and data) through multiple levels to and among forward, theater, and remote elements in a hostile environment. (N)

(3) Provide assured long distance communications (voice and data) with the rear areas, commensurate with needs, in a hostile environment. (A)

(4) Deny meaningful signal intelligence (SIGINT) data to the enemy. (P)

b. Some solutions for the surge phase, all distributed concepts:

(1) Primarily line of sight systems with HF as a backup. (A)

(2) Beam forming antennas. (A)

(3) A form of spread spectrum modulations. (A)

(4) Combined voice and data. (A)

(5) Links that go between radar type sensors could be integrated into a radar communications system. (N)

(6) A system of warning (ESM or other) that will enable evasive action if a communications emitter comes under direct attack. (P)

c. Some solutions for the sustained phase, Highly Distributed concept:

(1) A "utility" communications network that serves all TACS elements in the theater. (N)

(2) Air Force elements of the network are a part of a joint service theater-wide system consisting of "look alike" elements. (N)

(3) Semi-autonomous operating elements with relocatable system control. (N)

(4) Rapidly relocatable elements requiring no communications operators or maintenance personnel. (N)

(5) Automatic, self aligning antennas capable of multimode transmission or reception. (N)

(6) The network automatically maintains connectivity and load distribution among its elements. (P)

(7) All emissions are the same and continuous so that each element is a "look alike" to SIGINT. (N)

(8) Elements provide the interface for ground-to-air radio links; forward-area,joint service radio networks; and long-haul intra and inter theater communications as in other distributed concepts. (P)

(9) A common interface "plug" throughout the system. (P)

(10) All links are independently encrypted for transmission security. (P)

(11) Each classified user has his own encryption system for his information security. (A)

d. Some solutions for the sustained phase, Distributed concept:

(1) Communications equipment is mounted on trucks or vans for rapid movement throughout the theater. (N)

(2) Although there are no operations on the move, a rapid set-up and tear-down capability is needed. (P)

(3) Local area communications are to be over fiber optics or millimeter wave links. (A)

(4) Longer distance intra theater communications are to be done by fast setup, self-aligning, troposcatter or satellite or airborne relay or line-of-sight systems with HF as a limited backup. (P)

(5) Antennas are to be of the highly directional, beam steering type with low sidelobes. (P)

(6) Same as 6-7b(3), through 6-7b(5) above.

e. Some solutions for the sustained phase, Semi-distributed concept: The same solutions as for the Distributed concept except 6-7d(1) and 6-7d(2). In this concept, the communciations equipment is contained in transportable modules. (A)

6-8. Summary.

a. In air surveillance and airspace control, there is a fairly well organized program that supports the capabilities and solutions of the Semi-distributed and Distributed concepts. If the objectives of current and proposed programs are realized, the majority of the technical questions should be answered. This is not the case in the Highly Distributed concept where low cost, forward area radar nets capable of providing low altitude coverage are contemplated.

b. The surface surveillance activity appears to be well covered in sensor development. But, a distributed systems approach for the processing and use of individual sensor data is lacking. This holds true in all portions of the distributed spectrum and is not concept dependent.

c. The force management activity represents a major operational and technological challenge which is not yet receiving an appropriate amount of attention. Regardless of the concept, basic systems and technological problems exist. They only become more complex as the force management system is distributed into smaller elements.

d. Communications is very concept dependent. There are many programs addressing solutions for the Semi-distributed and, to some extent, the Distributed concepts. However, in the Highly Distributed concept, very little is underway.

7. CONCLUSIONS

Distributed systems tied together by assured communications offer the best means for the survival of command and control in a wartime environment. The most appropriate degree of distribution for a given conflict is largely dependent on the scenario and threat. The deployable TACS, which is designed to operate throughout a variety of conflict intensities, must have the flexibility to permit operations in all threat environments. Given the probable capabilities of future Soviet sensor and weapons systems, intra theater sanctuary required by the lesser distributed Tactical Air Control Systems cannot be guaranteed in any future major confrontations. If the deployable TACS is to be capable of operations in the most intense threat environment, it must be highly distributed.

8. RECOMMENDATIONS

Additional systems research into highly distributed systems should be pursued to develop a greater understanding of the features, means, implications, and costs involved. This research should include the impact of those functions listed in paragraph 3-8. In addition, an appropriate portion of the C^3 technology effort should be directed towards demonstrating the feasibility of highly distributed operations particularly:

a. Survivable distributed information systems including:

(1) Data bases

(2) Data distribution

(3) System control.

b. Assured communications to unite the operation including:

(1) Utility networks

(2) Multifrequency adaptive antennas

(3) Automatic load distribution and connectivity.

9. APPENDIX A

TACS-2000 WORKING GROUP MEMBERS

ESD/XRT	Maj John Morris Mr Otto Wech
ESD/XRC	Lt Steven Enke Lt Brian McKeon
RADC/DC	Capt Emanuel Sive
RADC/IR	Mr Lawrence Odell Mr Randy Hoffman
RADC/IS	Lt Col Wolfgang Goethert Lt Clyde Shook
RADC/OC	Mr Durwood Creed Mr Ronald Raposo
RADC/XP	Mr Don Brantingham
TACSO-E	Maj Robert Iversen
MITRE Corp	Mr Frederick Ellersick

DISTRIBUTION LIST

Air Force Systems Command
Andrews AFB, MD 20332
AFSC/XRK (2)

Defense Technical Information Center
Cameron Station
Alexandria, VA 22314 (12)

Electronic Systems Division
Hanscom AFB, MA 01731
AFGL/SULR (4)
AFGL/SULL (1)
ESD/CC (1)
ESD/DC (1)
ESD/IN (1)
ESD/OC (1)
ESD/TO (1)
ESD/XR (2)
ESD/XRC (2)
ESD/XRM (1)
ESD/XRT (50)
ESD/XRV (2)
ESD/YS (1)
ESD/YW (1)

ESD-Europe/CC
APO NY 09021 (2)

Rome Air Development Center
Griffiss AFB, NY 13441
RADC/CC (1)
RADC/DC (2)
RADC/IR (2)
RADC/IS (2)
RADC/XP (2)

Tactical Air Command
Langely AFB, VA 23665
TAFIG/II (2)

Tactical Air Command Systems Office
Hanscom AFB, MA 01731 (2)

DATE
FILMED
-8